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FOURTH CENTURY OF THE DISCOVERY OF AMERICA.

THE PORTRAIT OF QUEEN ISABEL—THE SEPULCHER OF KING FERDINAND AND QUEEN ISABEL IN THE ROYAL CHAPEL OF THE CATHEDRAL OF GRANADA.

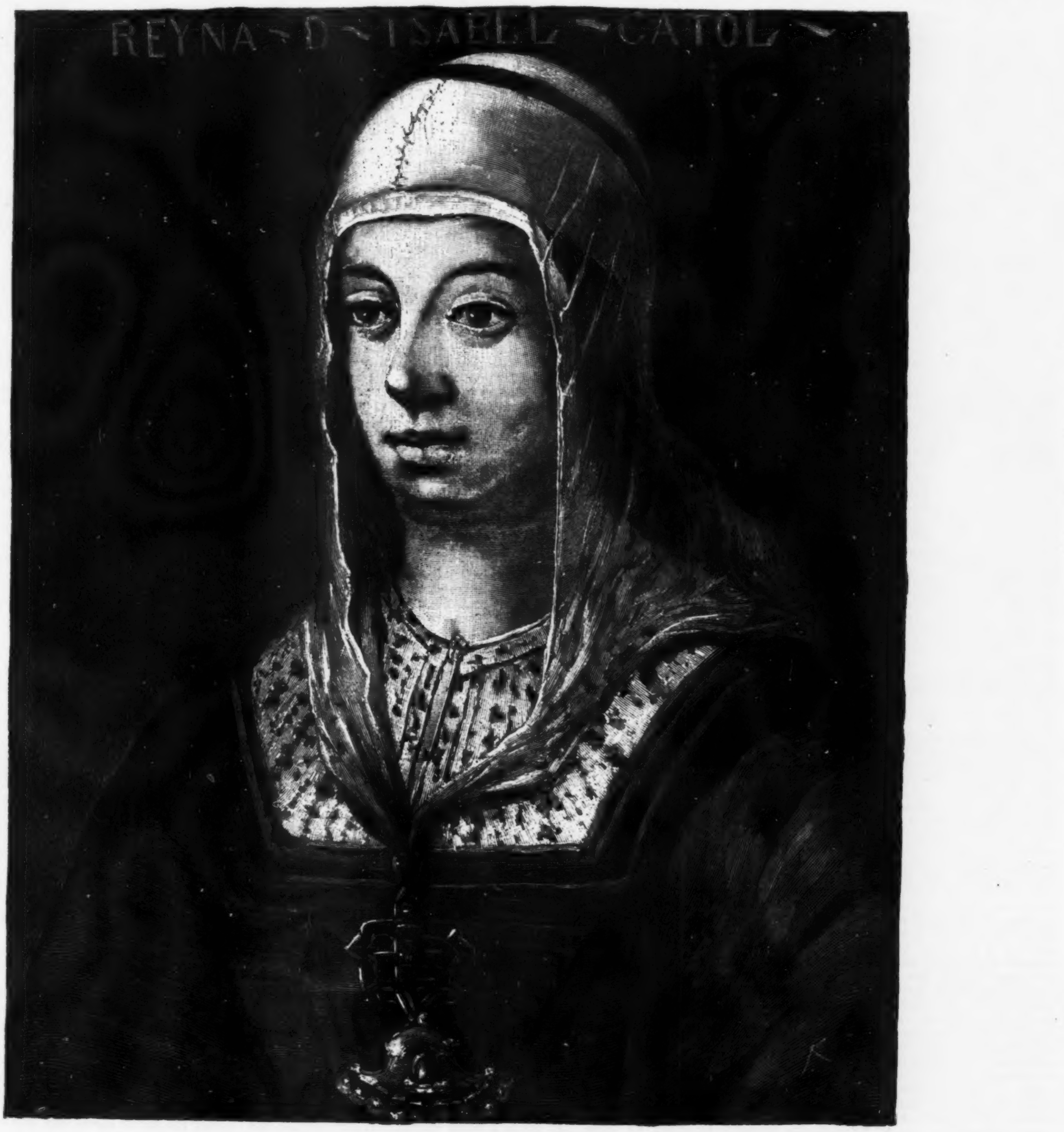
THE portrait of the excellent Queen Isabel la Catolica, of which we here give an engraving, is a copy from the original painting by Rincon, painter to the Catholic kings. It was formerly owned by a religious convent in Baza, but afterward passed into the hands of the Duke of Abrantes, who was a patron of that convent. From this several copies were made in oil by the Count of Donadio, and from one of these, dedicated by the illustrious painter to the poet Velarde, a faithful copy is given in the engraving which we here present. They may be assured that this portrait of the queen is the most authentic and was nearest to the epoch of the discovery of America; for which reasons, as well as the special circumstance that it never has been engraved until now, we have preferred to present it instead of any other portrait of the magnanimous queen. As may be easily seen, the work of Rincon has much resemblance to the head of the queen in the painting of the "Surrender of Granada" by Pradilla; who without doubt preferred it for his picture to all other portraits.

The cathedral of Granada, that sumptuous temple which Ferdinand and Isabella did not have the happiness to see inaugurated, was commenced in March, 1519, according to the plans of the illustrious architect Burgales Diego de Siloe, and the first mass was celebrated in it on August 17, 1566. The structure was finished under the successive directions of the architects Juan de Maeda of Sevilla and Juan de Orca, who constructed the palace of Charles V. and other works in 1636.

There is in the Metropolitan Temple contiguous to the chapel of Sagrario, and connected with it by a wide passageway which contains the sepulcher of the great Pulgar, that of the Ave Maria, another chapel which commands the most profound veneration of all good Spaniards, namely, the Royal Chapel, the Pantheon of the glorious conquerors of Granada, Ferdinand and Isabel.

Of Queen Isabel, said Peter Martyr of England, "Never was there any woman either in ancient or modern times, who was worthy to be compared with this transcendent lady." She died at half past eleven on the morning of Wednesday, November 26, 1504, having ordained in her now celebrated testament, which was signed on October 12 of the same year, that her mortal remains should be deposited in the Franciscan convent of Santa Isabel in the Alhambra, with no other monument than a cross and a simple inscription, until it should be sepulchered with her husband, for, she said in her will, "I wish that my body may be entombed with the remains of his Majesty, so that the union we enjoyed when living, and which our souls hope, in the mercy of God, will continue in Heaven, shall be symbolized by our bodies in the ground." An admirable sentiment of goodness and tenderness!

Her royal spouse, in the will which he signed on January 20, 1516, three days before his death, which took place in Madrigalejo, on the morning of the 23d, commanded that "as soon as we shall be dead, let our body be taken and entombed in our royal chapel, which we and her most serene Majesty, Queen Doña Isabel, our very dear and beloved wife, let her rest in



QUEEN ISABEL.—A COPY FROM THE ORIGINAL PORTRAIT BY RINCON.

glory, have caused to be made and endowed in the cathedral of Granada;" and this was done.

The Emperor Charles V., in tribute of homage and veneration to the memory of his illustrious grandparents, caused to be constructed a splendidly carved mausoleum, which we reproduce in our other engraving. This work of art is attributed to Felipe Vignardi, the famous sculptor of the cathedral of Burgos, in 1498 to 1532. It is executed in fine alabaster and is one and one-half meters in height, and embraces a precious combination of medallions, trophies and coats of arms, showing in its angles the imperial eagles. The recumbent statues of the monarchs present evidence of the most prolific and perfect workmanship. In the front panel there is seen the well known epitaph which commences thus: "The suppressors of the Mohammedan sect." In the same panel at the side of the royal mausoleum, there is erected also the sepulcher of the parents of the emperor Charles V., viz., King Philip I., the handsome, who died in Burgos, September 25, 1506, and Juana the mad, who died in Tordesillas, April 11, 1555.

For the foregoing and for our engravings, we are indebted to *La Ilustracion Española*. Philip I. was an Austrian prince, and was the husband of Juana, second daughter of Fernando and Isabel. Charles V., the Emperor, was the son of Philip and Juana.

THE APPLICATION OF METALS TO ARCHITECTURAL DESIGN.

At a recent meeting of the Royal Institute of British Architects, reported in the *Building News*, an introductory address was delivered by Mr. Alexander Graham, F.S.A., who traced the use of metals for decorative purposes from the remotest period, remarking that perhaps the earliest employment of ornamental metal work was the hanging of the leather shield studded with copper knobs in the hall of the chieftain. Having referred to the traditional origin of the art of casting in metals in Phrygia, Mr. Graham dealt with the development of the art in Egypt, Chaldea, and Assyria. In the two latter kingdoms metal working displayed, he showed, great magnificence and technical skill in execution, as we learned not only from the writings of Philostratus, the prophet Daniel, and other contemporary writers, but also from the fragments preserved in the British Museum and other collections. Persian art in bronze and silver was also glanced at. The earliest representation of the human form in metal was given us by the Egyptians, who, like the Assyrians, for ages cast in pure copper, and were for a long period ignorant of the fact that the metal could be greatly increased in hardness by the admixture of a little tin. The Jews were singularly deficient in ability to work in metal, and for Solomon's Temple skilled artisans had to be imported from Phœnicia. With both the earlier and later Greeks the application of metals to decorative purposes was of a restricted nature; but their productions were impressed with evidences of the genius which marked all their work. In touching upon Roman and Byzantine metal work, the author referred to the absence of originality which was apparent in both periods. At the dawn of the æsthetic Renaissance in Italy we first traced the germs of the new departure in this art, and throughout Europe its development was comprised between the twelfth and fifteenth centuries. In the Renaissance after the Reformation it was attempted to revive the art, but the spell had been broken. He regretted that the Greek revival at the beginning of this century was barren in results in this field, and that the Gothic revival which followed only gave us a few improved and more suitable forms for gas standards and other fittings; but indirectly we gained much from the study of mediæval work and the numerous illustrations of old examples.

THE PRECIOUS METALS.

Mr. C. Krall (Barkentin & Krall) read a paper on this subject, illustrated by some examples of cast and hammered work, both ancient and modern. He confined himself to the description of furniture decoration and small useful arts. It was, he observed, surprising, on investigating what parts of such work should be cast as against parts made of hammered plates, to find how limited was the legitimate use of casting in precious metal; while, apart from its intrinsic value, the quality of the heavier cast silver and gold work was very inferior to wrought. First among the legitimate uses of cast work was high relief sculptured work—that was, all such parts which would first be modeled in clay or wax, and which to work by hand meant a great deal of costly and tedious hand work, and necessitated a number of solder lines. Thus a figure or animal 4 in. high, with legs and arms or wings projecting, would be cast. Secondly, the decorated mouldings with patterns that repeat, and all such parts which, offering resistance, required greater thickness of metal than could easily be worked out of sheet metal. Thirdly, the number of repeating ornaments, perforated borders and crestings, of which a few copies only were required, and which would not justify the engraving of a steel die for stamping. A figure 18 in. high, however, would rarely be cast, particularly when modeled in high relief. This would be embossed out of thin plate as a whole or in sections, and soldered together or nailed down to the wooden or other foundation—a process used by the ancients, and in Byzantine art as well as in the present day. Precious metal was never cast in its pure and soft state, but was used in its harder alloys, the composition varying according to the color and the amount of hardness desired. The process of casting flat work, mouldings, and ornament was by the sand moulds; that of hollow work with sand cores and by the wax process. The latter was the better for uniform thickness. By sand moulds the thickness varied greatly, which caused the thicker parts, in cooling, often to fall in, which was very detrimental to the work, and often impossible to correct.

Knowing what parts should be cast, the designer would work with great advantage, and in many ways effect an easier and cheaper working. Silver and gold work was not in the present day estimated chiefly by its weightiness; the lighter it was, the more carefully it must be made, so as to be strong in all its parts. In designing silver and gold work it must be borne in mind that even plain mouldings did not always turn out satisfactorily in cast work; and that for all better work they were made in flat or turned up in sections of wrought tough metal, and joined together. Mouldings suitable for stone or wood should not be introduced. Examination of old works in the museums would show that the mouldings affording the greatest charm were mostly very indistinct, and often mere repetitions of lines or combinations of squares and round wires, with now and then a hollow and a twisted wire between. The old goldsmiths had no lathes and no machinery; they filed, engraved, swatched or rolled their mouldings; and for tracery work soldered one plate above another, with a round wire sometimes laid over it. He would advise designers to study the old work and learn its mysteries, and to let their work be carried out under its influence; then, whether cast or wrought, or made by any other process, the result would give satisfaction and delight both in the present and in the future.

CASTINGS IN IRON.

Mr. H. Longden, in the third paper, which was illustrated by models of wood, wax, and glass, and actual castings, remarked that in the usual process of iron founding, wooden models were made by skilled model makers, whose training was quite apart from that of a carpenter or cabinet maker. The sides of the model or any relieved parts must not be square, but slightly "stripped" or beveled to ease the draught from the sand. The model was laid on a board on the floor of the foundry, which was covered with sand, a cast iron casting box, called the "bottom box," was put on the board over the model, and the foundry sand sifted upon the model, first through fine riddles, until the whole surface of the model was equally covered with it, and then through a coarser riddle. The sand was carefully and evenly rammed with iron rammers until the box was filled. The whole was then turned over, and the board which was cramped to the box taken off, and the "top box" was put on, and the filling with sand and ramming process was repeated until the model was completely inclosed in evenly, lightly and yet firmly rammed sand. The making of the channels through which the molten iron was to be run into the sand matrices was an important matter, and had to be carefully arranged. The "top box" was then removed, and the model taken out, leaving a beautiful impress of the ornament, if any, in the sand, which was carefully dusted over with fine ground charcoal. Where the surface of a casting was to be full of ornament, the model was often put in again and evenly pressed upon the charcoal to give the fine surface seen on good castings; and this must be done with perfect accuracy of "register," the slightest inaccuracy blurring the impress. The two boxes were then cramped together again with iron cramps and wedged with wooden wedges. Casting with cores was another kind of moulding, and one requiring much skill and patience. If a great number of castings was required, instead of a wooden model, cast iron models were used. Wooden models were sometimes carved, and at others made the ground work of modeling in wax or in gesso if the effect desired were specially soft. There was also a pretty process called "reversing," by which a casting might be made from a solid block in plaster or wood. The choice of the iron for castings was an important matter, different mixtures being used for different castings. Most of the iron now used was smelted by "hot blast," but when great strength and tenacity were wanted the older fashioned "cold blast" was still utilized. When the iron was melted in the cupola the casting began. The furnace was "tapped" near the bottom with an iron bar, the white hot molten iron ran down a spout prepared for it into ladles of iron protected from being burnt by sand. The ladles were carried by the moulders to the casting boxes, and the molten metal poured through the channels into the place prepared for it in the casting boxes. When the iron had set, the top box was taken off and the casting taken up with the tongs, the loose sand about it removed, the gates knocked off, and it was reared up to cool until the next morning. Cast iron some time ago fell into a certain disrepute; but with the further study of materials it had been found that it had qualities of cheapness and usefulness as well as of reproducing a suitable model with perfect precision and delicacy. In designing for cast iron it was to be remembered that when the models were paid for, enrichments cost nothing if suitably applied. This facility for ornament, although a temptation to the unwary, in the hands of a master produced fine results. The ornament, if applied, should rarely rise to much relief. In his judgment, respect for the real conditions of the work to be done would produce a finer effect than clever *tours-de-force*, such as imitating wrought iron, stone, or wood in cast iron.

CASTING IN BRONZE.

The fourth and last paper was read by Mr. Herbert Singer, of Frome, who said pure bronze was simply nine parts of copper and one of tin. A vast number of alloys, however, were produced for different purposes, and the Japanese were said to use 200 distinct alloys; delicate colors depending on the alloy used. He believed the proportion of five parts copper and one tin was the alloy of the bronze implements of the ancients. It gave a hard substance, but would not suit many of the bronze productions of the present day. The brothers Keller, who worked in France in 1699, used for their alloy $9\frac{1}{2}$ parts of copper, $5\frac{1}{2}$ parts of zinc, $1\frac{3}{4}$ of tin, and $1\frac{1}{4}$ of lead for statuary work; others used only about 82 parts of copper. The sculptors during the Renaissance were often their own founders, and generally used a metal of good quality, in order that their work might not be injured in the casting. Mr. Singer thought bronze statuary would be a more exact reproduction of the sculptor's model if an alloy similar to bismuth could be found that would give no contraction. If bismuth were not so expensive, it could be used with great advantage in the composition of bronze. The subject of alloys led to that of soldering. The Romans had not used solder, but it evidently had been employed by the Saxons. The alloy for gold solder was silver, for silver solder silver and brass, and for bronze a mixture with brass made a good solder. The two processes of casting bronze into any required form were known as the "sand" and the "*cire perdue*." The founders of early ages used the wax or latter process; but it had not been and was not so much practiced in France as in Italy. Mr. Singer then proceeded to describe moulding by the sand process. For statues of more than life size it was necessary to have a lofty foundry in order to raise the large flasks from the pit in which the large pieces of metal were cast. The pit should be at least 12 ft. square and 10 to 12 ft. deep. The flask for a statue 10 ft. in height would weigh five or six tons, and should be so constructed of plates that it could be increased or reduced in size to suit the dimensions of the model. The model to be cast being then placed in the flask partly filled with sand, the preparation of the mould was commenced. The making of the mould would sometimes take three months, according to the number of pieces. The core had then to be prepared, and was a rough copy in sand of the original model, slightly reduced in size over the whole surface, the difference between the size of the core and the model giving the thickness of the bronze casting. The core was held in place by iron bars, so as to leave half an inch of space between the exterior face of the model and the interior face of the mould.

The mould and core being thoroughly dried, the flask was then lowered into the pit, and the molten metal run in. The flask, if all had gone well, being unscrewed, and the runners, or channels, which conveyed the metal to different parts of mould being cut off, there should be but little work to complete the bronze statue. For the "*cire perdue*" or "lost wax" process a very different method was followed. In this method, as now practiced, the plaster moulder and the bronze founder relieved the sculptor of the mechanical part of the work. The sculptor modeled the work in clay or wax, the plaster moulder reproducing it in plaster, making probably several copies; one was handed to the bronze founder, whose first duty was to make an exact reproduction in moulder's wax, with a core inside it. He might effect this with a gelatine or a piece mould—according to the subject. If a piece mould, the work was laid down and the lower part covered with clay; upon the upper part the liquid plaster, of the consistency of thick cream, was moulded into appropriate forms fitting together; the whole being protected and kept together by one large outside piece. The upper part being completed, the work was turned over, the clay from the lower part removed, and it was treated in the same way as the upper part. If using gelatine, the moulder covered the work with clay of the thickness the gelatine needed to be, and on the clay he formed two coats of plaster to keep the work steady. The clay was then removed, and the gelatine poured into the place it had occupied—a mould of gelatine being the result. Having, whether by the piece mould or gelatine method, obtained a complete mould, the moulder formed a core inside it. The mould being taken apart, the core was pared down to allow as much space between it and the mould as the metal should occupy. The mould being put together again with the pared core inside, the wax was poured in, producing an exact reproduction of the original model. The wax was then handed to the sculptor, who removed all seams and generally "touched it up." Being returned to the moulder, he then made the mould to form the metal, which mould was composed of a substance kept secret by most founders, applied in layers until there was a tolerably thick coating all over the work. A cage made of iron was then formed round the work, and sand rammed between the spaces. The whole being placed in a muffle, the wax was melted out by means of gas, the mould thoroughly dried, and, while still hot, taken out of the cage, and, if necessary, placed in an iron flask and the metal poured in. It only remained to open the mould, remove the core, clean the casting, take off the runners, and apply the patina. An eminent sculptor had described the wax method of bronze founding as an art, the sand as a trade. He (Mr. Singer) considered that an exaggeration. For some works, and where cost was an object, the sand process was the best. For others, especially where casting of the highest excellence was required, the wax process was the one to use.

Small models of the Chatham statue of General Gordon, seated on a camel, and a figure of Peace, both by Mr. Onslow Ford, and illustrated in our pages when on view at the Academy on June 13, 1890, were exhibited as examples of the success that could be achieved with the *cire perdue* process.

Mr. J. M. Brydon, Chairman of the Arts Committee, by whom the evening's papers had been arranged, proposed a vote of thanks to the four readers. He objected to one of Mr. Krall's reasons for recommending the use of cast work in precious metals that it saved time, for quality of execution was the great requirement in objects made of silver or gold, and architects were willing to sacrifice time to obtain it. He greatly preferred the *cire perdue* to the sand process for all statuary, as the former method gave a better surface and necessitated less intervention by the modeler and moulder between the sculptor and the finished production.

Mr. E. Onslow Ford, A.R.A., said the real difference between the sand and wax processes of casting was that by the sand method the actual sculptor was five times removed from the executed work, whereas by the wax method he was but twice removed; indeed under the latter mode the differences were so slight that it was possible to make what was practically an exact reproduction of the artist's model. He bore testimony to the excellence with which Mr. Singer had carried out his works.

Mr. George Simmonds corrected Mr. Singer as to Cellini's practice; he had implied that in the 15th century, if a wax casting were unsuccessful, the model, and consequently all the preliminary labor, was lost; but Cellini told us that he made a piece mould to fall back upon. Mr. Singer had spoken of the metal of the wax mould as a trade secret. He did not think such trade secrets should exist in these days; but, as a matter of fact, the composition of the metal was very well known, and he himself possessed five or six different recipes, all written down. As a rule most founders adhered to one mixture, which in their practice proved satisfactory. As for the relative merits of the sand and wax processes, he always adopted the latter for the face and hands of a statue, as by it the

minutest touch could be exactly reproduced, but did not think it necessary to the casting of, say, a frock coat, and for the body used the sand method.

Mr. Starkie Gardner differed from Mr. Graham as to the most ancient metal work. He believed that all work which we regarded as prehistoric was cast, and not beaten, and that it was run into moulds of porous stone which gave somewhat of the effect of sand casts. In the time of Charlemagne, the Germans were certainly able to cast in brass, an example being the railings at Aix-la-Chapelle. Much of the beauty and richness ascribed to Eastern metal work must, he feared, from the examples which had been examined, be put down to Oriental exaggeration.

Professor Aitchison, A.R.A., seconded the vote of thanks, and mentioned that some time since, in decorating the interior of a country house, the owner wanted a range of capitals to be alike. After one had been carved in mahogany, Mr. Alfred Gilbert, A.R.A., was commissioned to design one to be cast. The series was reproduced in bronze from this model at a much lower cost than it would have cost in mahogany. He did not see why bronze castings should not be employed for work removed to a considerable height from the eye, when all hand carving would be thrown away. Unlike many of his brethren, he anticipated that cast iron would be more largely utilized in future

TOMBS OF FERDINAND AND ISABEL AND OF THEIR CHILDREN, IN THE ROYAL CHAPEL, GRANADA.

architecture, and that it would compel a return to a trabeated style.

Mr. H. H. Statham said the question of durability would affect the use of iron. Sir Benjamin Baker once told him that he estimated that with careful usage the Forth Bridge might last five centuries, and if this was the maximum life of soft steel, what could be expected of cast iron?

Mr. W. White, F.S.A., differed from Mr. Krall to some extent as to the usefulness of cast metal, and thought that many of the examples of old gold and silver work which he showed would have been improved had all the ornamentation been wrought and not cast. For larger work, castings were admirable.

THE CUNEIFORM INSCRIPTIONS OF WESTERN ASIA.

By JOSEPH WALLACE.

IN the March issue of *Popular Science News* we stated that the first advance in deciphering cuneiform writing was made after the return of Niebuhr from the East. During the century and a half that elapsed since the time of Fuqueroa and Della Valle, numerous speculations as to the nature of these inscriptions had been published. Mr. Hyde, an oriental scholar of eminence, considered them mere idle fancies of the architect, who wished to show how many different combinations of a single stroke could be made, and regretted that he had wasted time upon them. Witte, of Rostock, thought they were marks of the work of generations of worms. Others believed that they were talismanic signs, formulas of priests, astronomical symbols, charms, etc.; and not a few held the opinion that the characters represented the Chinese, Cufic, Hebrew, Greek; and even the Runic of Northern Europe was mentioned. Those whose opinions were the most absurd were the most earnest in expressing them.

Time passed in venturing opinions quite plausible, while others were wide of the mark. The first real step in the solution of the problem was made by K. Niebuhr. He did not intend to interpret the inscriptions, but rightly conjectured that those of which he had published copies were written in three different languages; and although he was not sure, yet he supposed the same text was written in each of the three alphabets. In 1798, Tychson, of Rostock, and in 1800, Munter, of Copenhagen, attempted to further Niebuhr's theory; but all they really accomplished was to attain the correct conjecture that a frequently occurring group of characters represented some word signifying a king, and that a single wedge frequently occurring, placed in an oblique direction, pointing downward and to the right, was employed to separate the words.

Such was the condition of the problem previous to 1802. On Sept. 7 of that year, G. F. Grotefend, then twenty-seven years old, presented to the Academy of Science of Gottingen his first attempt at deciphering the cuneiform alphabet. Grotefend endeavored to establish that the inscriptions were in some kind of writing, and that their chief characteristic was the absence of all curvatures, in consequence of which they were especially fitted for cutting in stone and other hard materials; and it is true that no direct evidence of the employment of sphenography in any manner except upon stone or clay hardened by heat, or materials of a like nature, has been found.

Grotefend confined his attention to the first, or simplest, kind of cuneiform writing. He remarked that all the horizontal wedges pointed toward the right or downward to the right, while the inner angle of the arrow head always opened to the right; hence he concluded that the writing was to be read from left to right. He further concluded that the inscriptions probably belonged to the age of the Achæmenian kings of Persia, and he determined to compare the names of those kings, as given by the Greek historians, with some of the first words of the inscriptions. He conjectured that the two combinations of characters occurring in the inscriptions represented the names of kings who were father and son, and he endeavored to ascertain which of the Greek names of the Persian kings the characters probably represented. They could not be Cyrus and Artaxerxes, for the first seemed to be too short and the second too long in proportion to the characters. The names of Darius and Herxes were free from these objections; Darius and Herxes were father and son, their names commenced with different letters, and they seemed about the right length. Grotefend was correct, and the first step in the solution of the problem was made. But he was not able to complete it, owing to the small number of copies of inscriptions in his possession, and also failing in possessing the knowledge and means essential to complete success.

The next important discovery was made by R. Rask. In his work on the Zend language (1826), he determined the value of two characters representing *m* and *n*, which Grotefend interpreted differently. No farther progress was made for the next ten years, but the majority of oriental scholars were led to believe that a starting point had been discovered by Grotefend, which would, by the aid of more copies of inscriptions for comparison, lead to favorable results.

In 1836 two works appeared almost simultaneously by two of the greatest oriental scholars in Europe—E. Bournouf, of France, and C. Lassen, of Germany. Each had worked entirely independent of the other, and both determined the value of other characters. From this time many scholars had not at hand a sufficient number of inscriptions to make progress until 1839, when the widow of Mr. Rich, an Englishman, who had resided many years in Bagdad, published from manuscripts left by her husband several additional inscriptions, which they copied with great care. In 1845, N. Westergaard returned from a scientific journey in the East, and brought copies of several new inscriptions. Three different persons, widely separated, discovered the key to the difficulties, which, until then, defied the learning and skill of the best oriental scholars. The names of these distinguished men will always be regarded as the real discoverers of the true system of reading cuneiform inscriptions: H. C. Rawlinson, of England; Rev. E. Hinks, Killyleagh, Ireland; and Julius Oppert, of France. Rawlinson and Oppert possessed many advantages in the way of a more thorough examination of inscriptions, and better facilities for copying and exchanging ideas, than had Rev. E. Hinks, who resided in an obscure village. Great as were Rawlinson and Oppert, who enriched oriental literature by their works, Rev. E. Hinks, of Ireland, was the most gifted Assyriologist, considering his limited opportunities, of the nineteenth century.

While Bournouf, Lassen, and others were prosecuting their labors in Europe another investigator was at work in the country where the inscriptions were chiefly found. H. C. Rawlinson, whose name we have already mentioned, a young Englishman in the military service of the East India Company, had been sent to Persia in 1833. He knew nothing of what had been done in Europe—not even the labors of Grotefend. He commenced with inscriptions found at Mount Elvend, near Hamadan, a city northeast of Kirmanshah. In 1837 he copied the first column of the great Behistan in-

scription and four of the smaller inscriptions. In the same year he became acquainted with Grotefend's and Bournouf's works. In 1839 he had already deciphered and interpreted with a great degree of accuracy the whole of the Behistan inscription, when the breaking out of the Afghanistan war rendered necessary his transfer from the field of his discoveries to that of military service in the latter country. However, in 1844 he was finally able to present to the Royal Asiatic Society complete copies of the Persian portion of the Behistan inscription.—*Popular Science News.*

RIGHTING OF THE THREE-MASTED COLLIER LA FEDERATION.

MR. NOURY, assistant engineer in the navy, has given an account, in the *Revue Maritime et Coloniale*, of the operations performed for the righting of the three-masted vessel La Federation, which capsized near the naval coaling station at Toulon, just after it had discharged its cargo. This sailing vessel, of about 2,400 tons displacement, carries a load of 1,800 tons. It is 230 ft. in length by 33 ft. beam. As it was low tide, the vessel, whose draught without cargo is only 7 ft., had 25 ft. of water under its keel and could not strand. It did not have to sink, because the stay of the mainmast was placed across the landing stage and permitted of sustaining the vessel, while the lower yards rested upon the mud.

The hatches, which had remained open, were first closed, and then the stay of the mainmast which had caused the subsidence of the landing stage was cut away. The vessel immediately inclined, and its masts made an angle of about 15° below the horizontal. In order to right the vessel, the chief of the naval division decided to proceed as follows:

1.—To prevent the vessel from inclining any more, and to this effect to connect the head of the masts with fixed points, and, in order to moderate the stress to be supported by the latter, to place ballast upon the vessel's keel.

2.—To so manage that the vessel should not sink if a leakage occurred at the joints of the hatches or in the seams of the deck, and, to this effect, to install pumping apparatus.

3.—After clearing the vessel of everything that might interfere with its being set afloat, to cause the righting apparatus to act upon the head of the masts, while moderating the motion by guys.

In order to carry out the above programme, there was placed at the extremity of the mainmast and of the foremast two shears designed to carry winding tackles lashed to the extremity of the lower masts. These tackles were capable of supporting a stress of about 30 tons. There were placed upon the keel six old boilers having an approximate weight of 95 tons, the slings of which were fixed to the heel of the masts.

Righting Apparatus.—(1) It was possible, as has been stated, through the tackles and shears, to exert a stress of about 30 tons; (2) it was possible to cause a shear hulk of a power of 15 tons to act at the extremity of the foremast, and a large hulk of a power of 50 tons to act at the extremity of the mainmast.

Steadying Apparatus.—In order to prevent the vessel from righting with too sudden a motion and careening on the other side:

(1) There were lashed to the extremity of the lower masts three tackle guys.

(2) Two lighters, one of 40 and the other of 15 tons, connected by chains to the head of the lower masts, were installed. Any length desired could be given to these chains, and the vessel arrested at any point whatever of its course; and the keel ballast could be suppressed, and the motion thus be moderated.

Let us add that the vessel was held in position by bow and stern fasts.

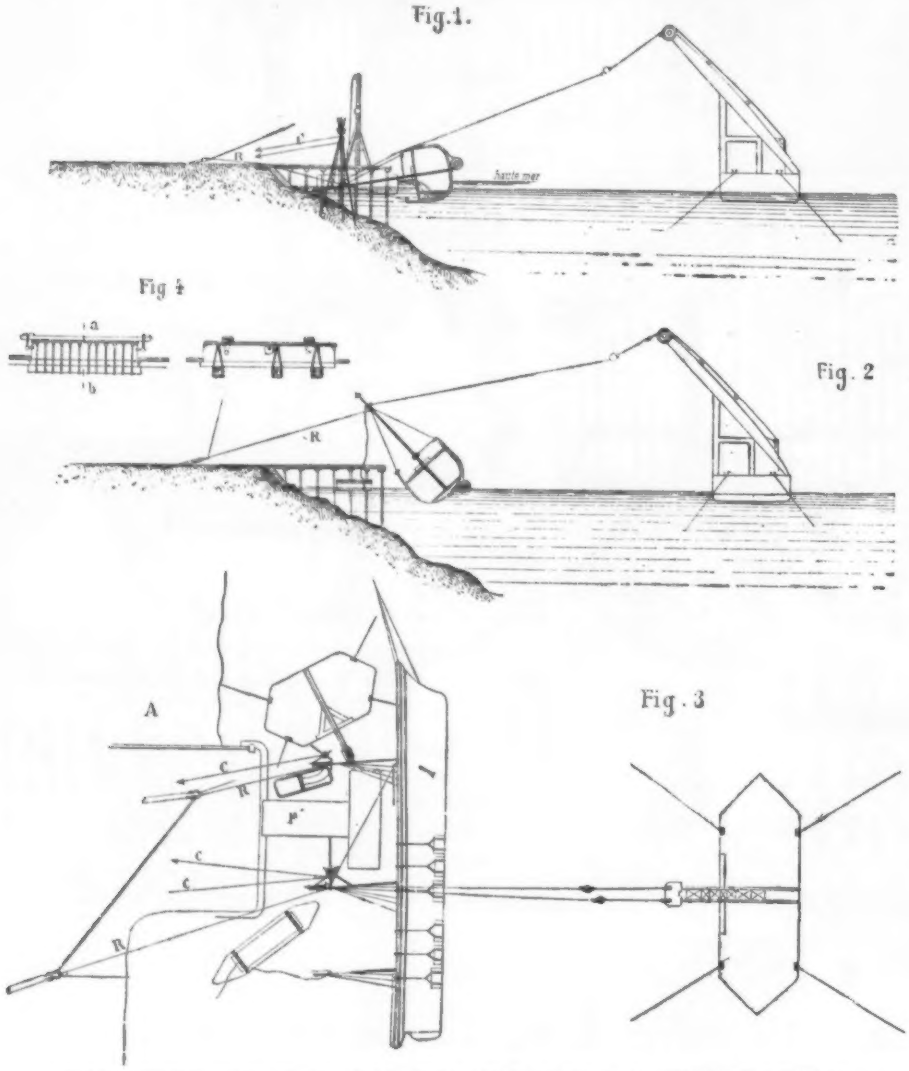
Details of the Operation.—A beginning was made by placing the shears and tautening the supporting winding tackles. The vessel was cleared of everything that could impede its motion. The topmasts were cut away, and the lower yards which, inserted in the mud to a depth of about 20 ft., would have presented a great resistance, were unshipped.

Six boilers, weighing 95 tons, were placed upon the keel, and their slings were fixed to the heel of the lower masts. The water was removed from the hold by the fire engine of a ship's boat belonging to the Directorship of the Movements of the Port. The water that had entered through the joints of the cover of the main hatchway rose to 5 ft. in the interior.

At this period of the operations (August 25) the vessel had as yet shown no tendency to right itself.

After the chains of the lighters had been wound up by a length of 10 ft., the two shear hulks were set to work. In measure as the vessel turned up, the righting tackle was hauled in and the tackle guys were surged. After the masts had exceeded the horizontal, the vessel began to righten of itself. In order to support it by the tackle falls of the righting apparatus and to have the maneuver under control, the slings of the boilers were then cut, and the motion was afterward continued until the righting tackles came block to block.

On the next day the shears were removed, and the two hulks were set in operation, in giving more and more length to the chains of the lighters. No incident occurred until the vessel had been brought to within 12° of the vertical, when the operation was considered as terminated; and the captain of the vessel finished by putting it on an even keel through the introduction of 80 tons of sand into its hold.—*Le Genie Civil.*



RIGHTING OF THE SAILING VESSEL LA FEDERATION.

FIG. 1.—Profile of the vessel after capsizing and at the beginning of righting it. FIG. 2.—Profile of the vessel during the righting, with an inclination of 45°. FIG. 3.—Horizontal view of the vessel at the beginning of righting it: A, arsenal; C, current; F, landing stage; R, tackle guys. FIG. 4.—Arrangement of the battening of the hatchways.

THE DANGERS OF PETROLEUM CARGOES.

AT a recent meeting of the Institution of Naval Architects, Mr. J. H. Heck read a paper on some experiments with inflammable and explosive atmospheres of petroleum vapor. In the course of his paper the lecturer said: Models to a scale from ⅛ of an inch to 1 inch to a foot were made of the tanks of a petroleum steamer; tubes and tanks varying in size and up to 6 ft. and 12 ft. high were also used during the course of the experiments. The petroleum used consisted of samples of crude and refined oil which had actually been carried in bulk; a quantity of petroleum spirit had also been experimented with. With the samples of refined oil supplied (both Russian and American) up to 70° F., even with no ventilation, no inflammable or explosive atmosphere could be formed. At temperatures much above 80° F., however, with no ventilation, such an atmosphere could be formed with a number of the samples. With nearly all the samples of crude petroleum, and especially the spirit distilled from crude petroleum, an inflammable or explosive atmosphere of petroleum vapor could be speedily formed with temperature from the freezing point and upward; atmospheres of oxygen especially could be made highly explosive in the course of a few minutes. The atmosphere inside the tanks was made inflammable or explosive at temperatures up to 65° F. by natural means, certain measures of crude oil being put into the tanks, the air which they contained was made inflammable or explosive by the vapor which was given off by the oil. At temperatures in excess of this, the excess of temperature was produced by a water bath. The condition of the atmosphere in the tanks was first tested as to its inflammability or explosiveness by the direct application of a flame or electric spark. In order to ignite an inflammable or explosive atmosphere of petroleum vapor a very high temperature is necessary. A red hot piece of metal or coal or a spark from steel or flint will not ignite such an atmosphere. A white hot piece of metal, a flame, or an electric spark will readily do so, and this latter fact should be known by every one employed on petroleum steamers, as there seems a very general opinion that with the electric light there is no danger. As many safety fuses and switches often give a spark, no such electric light fitting should be placed in the 'tween decks, pump room, or any other spaces where petroleum vapor may be present; very good reasons can also be given against the use in such places of portable electric lights which require a flexible cable with a lead and return wire. While a red hot rivet will not ignite an inflammable or explosive atmosphere of petroleum vapor, a white hot rivet will do so. Again, when a rivet which is only red hot is placed in the rivet hole, a small flame is often produced even when the plates are wiped as clean as practicable. This small flame is no doubt due to the presence of small quantities of oil or the solid constituents of the oil. Again, a flame can also be produced by dropping a red hot rivet on a piece of paper or chip. It therefore appears that during repairs, whenever a vessel is fit for red hot riveting, it is also safe to use naked lights. One important note about petroleum vapor is its high specific gravity, it being roughly from 3 to 3½ times heavier than ordinary air. In testing the condition of the atmosphere inside a petroleum tank, if the air at the bottom is found not inflammable or explosive, the air above is sure not to be so. In the experiments, especially with the deep tanks, the air at the top was often found on testing with a syringe and naked light to be practically free of vapor, while on applying a light at the bottom an explosion was caused. A small quantity of some kind of crude petroleum will render a large space explosive. Of three of the samples tested, one volume of the oil would render respectively, giving round numbers, 180, 400, and 600 volumes explosive. A tank full of even crude petroleum appears to be quite as harmless as one containing coal, especially so if the air is excluded. The surface of the crude oil in a comparatively large tank was often purposely ignited by means of a fierce flame. The fire, however, could at once be put out by simply putting on the cover or cap, and thus preventing the admission of air. It is the vapor given off from the oil which renders the use of naked lights, or any artificial light, dangerous. When a tank is nearly empty, the oil remaining, if it contains any spirit, may speedily render the atmosphere inside inflammable or explosive. When the atmosphere is in that condition it would be a good rule not to enter the tank with any other light except sunlight, and there is very little doubt that many of the members of this institution could design a petroleum steamer so that the tanks, when required, could be cleaned without the aid of any artificial light. When once the oil has been wiped out, the tank can be quickly cleared, and kept clear of any explosive atmosphere by very simple and inexpensive means. There are good grounds for assuming in vessels engaged exclusively in the carriage of refined petroleum in bulk, at ordinary temperatures, that daily tests would show that generally they are comparatively free of vapor, and that the only time the atmosphere they contain is inflammable or explosive is when the tanks are being steamed. The extra temperature which is produced by steaming causes petroleum vapor to be formed, even from refined petroleum, and anything which does that appears to be something which should be avoided. Many experiments were made with the model tanks—which were of tin or zinc—in order to ascertain what effect wind sails and hatchway area had in purifying or preventing the formation of an inflammable or explosive atmosphere of petroleum vapor. After repeated trials the conclusion was arrived at that results obtained with small models were not trustworthy indications of what would take place in a large tank, for one reason, the conditions not being equal. For instance, in two tanks, one having twice the dimensions of the other, while the internal surface of the larger tank would be four times, the cubic contents would be eight times that of the smaller tank. If both tanks were consequently full of vapor, and the hatchway areas were made proportional to the surface exposed, in the larger tank twice as much vapor would have to escape per unit of hatchway area in order to free both tanks in the same time. The general deduction drawn from the experiments was that, unless oil was entirely removed from the tank, certain conditions might arise which would tend to make the atmosphere at the bottom in-

flammable or charged with petroleum vapor. As the production of vapor, other things being equal, is proportional to the surface of the oil exposed, a small quantity spread over a large surface, such as could take place by a small leakage of crude oil in the 'tween decks, would tend quickly to make the atmosphere inflammable; and, although the number and area of ventilators fitted usually in the 'tween decks, under such circumstances, if properly trimmed, might, on testing, be found sufficient to prevent the formation of such an atmosphere, when the vessel is steaming against a head wind, in a calm it is doubtful if they would do so. While, no doubt owing to the great density of petroleum vapor, it appears to be a question of time to get rid of it by diffusion or upward displacement, the tanks used in the experiments could be quickly cleared of it by the method of downward displacement—a method used in the manufacturing arts to get rid of large quantities of carbonic acid, which has, roughly, only a density of about half that of petroleum vapor. While not in any way attempting, from experiments on such a small scale, to draw any deduction in regard to what would be found on making tests with the large tanks of a steamer carrying petroleum in bulk, the experiments appear to show that, while any vapor that may be present cannot be got rid of in a few minutes—as some have asserted—by simply giving a little hatchway opening or a windsail at the top, they also show, on the other hand, that petroleum steamers, especially those carrying refined petroleum at ordinary temperatures, are quite as safe as many vessels carrying some kinds of coal; and that, if all the officers and engineers on these steamers had a more general knowledge of some of the elementary properties of petroleum and petroleum vapor, daily tests were made of the condition of the contained atmosphere, and ventilating fans or air pumps were fitted, so that if any vapor were found it could be readily pumped out, petroleum steamers and their cargoes would be among the safest afloat.

BRADLEY DRAW-CUT LUMBER-CUTTING MACHINE.

THIS machine operates a large knife, running from 30 to 40 strokes per minute, which, at every stroke, cuts a perfectly smooth board from the log, boards 8 feet in length, and any width up to 3 feet, and from $\frac{1}{16}$ of an inch up to 1 inch in thickness.

Will easily cut 30 per minute, and run 23 hours out of 24.

It saves all loss of material from sawdust and planing.

Cuts boards of many thicknesses; no steaming necessary to prepare them; and many kinds of wood without waste.

The whole log is utilized, and the fiber of the wood remains perfectly sound without check or break.

The machine is 42 feet long, 8 feet high and 15 feet wide; weighs 42 tons; can be run by steam or water power. The object of this invention (which may largely do away with the saw) is to economize time and the lumber itself.

Tabular Statement of Loss in Material by Sawing and Planing, which is all saved by the Use of the Lumber-Cutting Machine.

$\frac{1}{2}$ inch, dressed 2 sides, loss in sawdust $\frac{1}{8}$, loss in planing $\frac{1}{16}$, total loss, 37½ per cent.

$\frac{3}{8}$ inch, dressed 2 sides, loss in sawdust $\frac{1}{8}$, loss in planing $\frac{1}{16}$, total loss, 50 per cent.

$\frac{1}{4}$ inch, dressed 2 sides, loss in sawdust $\frac{1}{12}$, loss in planing $\frac{1}{16}$, total loss, 58⅓ per cent.

$\frac{3}{16}$ inch, dressed 2 sides, loss in sawdust $\frac{1}{12}$, loss in planing $\frac{1}{16}$, total loss, 116⅔ per cent.

$\frac{1}{16}$ inch, dressed 2 sides, loss in sawdust $\frac{1}{12}$, loss in planing $\frac{1}{16}$, total loss 233⅓ per cent.

Besides the above saving in material this machine makes a great saving in time and labor over any other known process of cutting lumber, and absolutely does away with all planing machines and the labor attending them.

The knife is 3 feet long, and weighs (with its carriage) 500 pounds. It works with a draw motion, which prevents the fiber of the wood from breaking. The knife is moved by a wooden connecting rod, fastened to a wheel 10 feet in diameter. Every revolution of this wheel makes a board. The machine is fed by an apparatus which is controlled by two screws, connected by a chain gear, so that they move with absolute accuracy, making boards exactly the same thickness from one end to the other. A system of cog wheels regulates the thickness of the board. Total output of the machine is 80,000 feet per day.

Productions in woods (which on account of the great saving in time, labor and material) this machine must be found indispensable for the manufacture of: Cheese boxes (best in the world), barrel staves (made with positively no checks on them).

Picture and looking-glass backs, boxes of every description, such as cracker, starch, tin, plate, sapolio, jewelry, orange and lemon, fruit boxes (made of birch and shipped all over the world), honey, and all kinds of wooden boxes used by wholesale grocers, druggists, etc.; in fact, when you go into the realm of boxes and consider that this machine covers the whole field and *makes them all without loss*, you begin to fully realize the importance of this invention.

Then, again, we have veneers and woods of all kinds for lining of cars, interior decorations of houses, boards for rolling cloth on, used by manufacturers all over the world, and which now have to be covered with paper to prevent the cloth from being cut.

Trunks of every descriptions, pails, butter firkins, washtubs, etc. In fact, the industries which this invention covers are almost too numerous to mention.

A NEW SPEED INDICATOR.

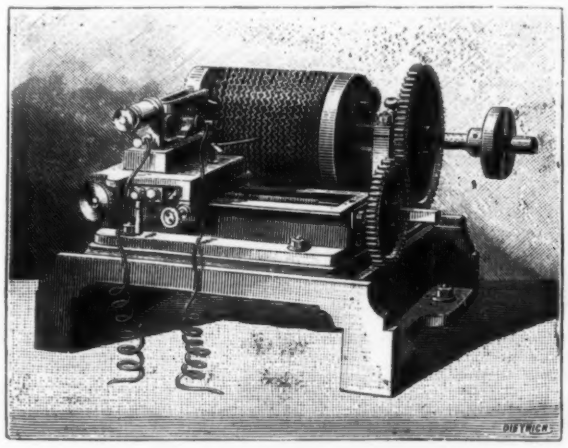
IN the majority of experiments in mechanics the indication of angular velocity is one of the most important of matters. Engineers who have to make trials of steam or electric motors, and those who have to watch such motors in their ordinary operation, must know their angular velocity, which is certainly one of the most important factors of their action. In most cases, the engineer is content to take, through the aid of an appropriate counter, the number of revolutions made within a given time (per minute, for example), and these observations are repeated as often as possible; but very precise data are far from being obtained as to the continuous angular velocity of the engine experimented upon. In order to have accurate indications, it is important to note the velocity at every instant and to preserve a written proof of it that may be joined to the diagrams of the indicator card of the steam engine or to those of electric apparatus. Several systems of this kind have already been constructed. We now propose to make known a new one, which is very well conceived, and that is the speed indicator of Messrs. Manlove, Alliott & Co., which permits of determining the time during which a shaft revolves, to within nearly $\frac{1}{5000}$ of a second, and which gives a written trace of the velocity that it registers.

The apparatus consists of a cylinder set in motion by the shaft whose angular velocity it is desired to measure. A special gearing actuates a slide that carries a tuning fork placed opposite the cylinder. The tuning fork is provided at one of its extremities with a small style which bears against the cylinder and traces characters thereon. When set in motion, it makes a certain number of vibrations which remain always the same per second or vary only within very narrow limits. In the present case, the number of vibrations is 512 per second. The tuning fork is kept in operation by means of an electro-magnet supplied by a battery. A beginning is made by placing a sheet of rather strong paper upon the cylinder. To this effect, the two extremities are passed into a narrow slit that extends throughout the entire length of the cylinder. Then the ends are drawn by means of peculiar rollers placed in the interior of the drum. The pressure necessary to tighten the paper is assured by screws.

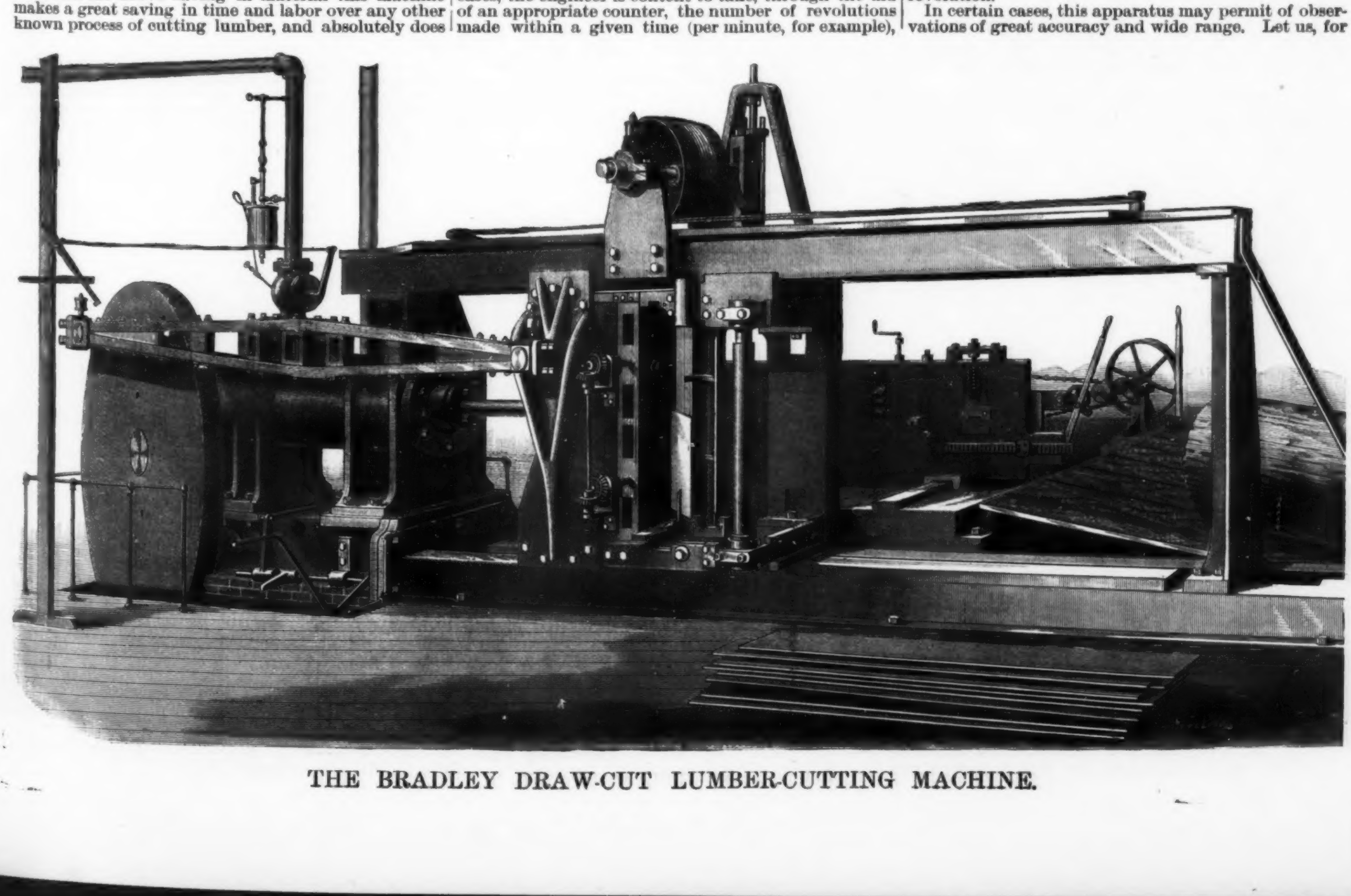
It is necessary afterward to blacken the paper by means of an oil lamp with a wide, flat wick, which is placed beneath. The cylinder that carries the paper is slightly shifted until a sufficient and regular deposit has been obtained. It is well to take precautions against the paper being burned.

When the cylinder is thus prepared the tuning fork is arranged and set in vibration, and the cylinder is revolved, care being taken to note the starting point. The style of the tuning fork, in displacing itself, registers the successive vibrations, each of which represents an exact part of a second—1-512th. It will therefore be very easy to count the time taken to effect a complete revolution.

In certain cases, this apparatus may permit of observations of great accuracy and wide range. Let us, for



NEW SPEED INDICATOR.



THE BRADLEY DRAW-CUT LUMBER-CUTTING MACHINE.

example, take an installation of dynamo machines. It is important that the angular velocity shall remain constant within quite narrow limits.

The indicator under consideration will permit us to register the slightest variations in velocity to within about 1-5000th. It is, in fact, very easy to appreciate a tenth of a vibration. Some comparative experiments have been made upon several motors in order to ascertain the limit of the possible variations. These have shown that the variation in velocity is 5 per cent. in a steam engine and 6·25 per cent. in a gas motor.

Messrs. Manlove, Alliott & Co.'s apparatus will permit, as we have above stated, of preserving written proofs of various experiments. It suffices, in fact, to pass lac varnish over the blackened sheet of paper in order to fix the inscriptions.

The advantage of this apparatus is that it gives the indication of the velocity very accurately at every instant.

As long as the velocity remains normal, the cylinder revolves with a regular motion, and vibrations of the same velocity are registered; but when the number of revolutions increases or diminishes, the vibrations become more widely or narrowly spaced upon the paper. It is easy to construct a small registering apparatus of this kind for laboratory use.—*La Nature.*

APPARATUS FOR THE COMPRESSION OF AIR FOR THE PARISIAN COMPRESSED AIR COMPANY.

IN order to aid in the development of the consumption of compressed air, which the works of Saint Fargeau street were no longer able to satisfy, the Parisian Company has just established a new central station. Constructed upon the banks of the Seine, at Quay De la Gare, the new works are established under much more favorable conditions in all respects than those of Saint Fargeau street, and will permit the Parisian Company to reduce the cost of production in a very notable degree.

The site of the works is all-sufficient for the installation of a motive power of 24,000 horses, and it is in view of such power that have been established the new compressed air mains that connect the works with the distributing pipe line, as well as the aqueducts and the culverts that carry water from and to the Seine.

The 24,000 h. p. will be furnished by three like groups, each composed of four 2,000 h. p. engines and four batteries of multitubular boilers with economizers.

The first group, as a whole (8,000 h. p.), is now in service.

The steam boilers, which are of the Babcock & Wilcox type, were constructed by Messrs. Schneider & Co. at Creusot, as were also the four 2,000 h. p. motors

We shall not at present undertake to give a detailed description of the works, but shall confine ourselves merely to a description of the machines for compressing air. These latter, moreover, constitute the most interesting and original part of this important installation.

The engines are vertical, and have three cranks and a direct action. The compressing cylinders are placed above and in the prolongation of the steam cylinders. The motive apparatus is a triple expansion one, and the air compressor, which is of the Riedler system, is compound, with three cylinders.

The boilers are registered at 26 lb., and the steam is admitted at a pressure of 22 lb. into the small cylinders. The compressors are established for forcing the air into the reservoirs of the works at a pressure of 17 lb.

The normal velocity of the engines is 60 revolutions per minute, but these engines are so established as to be capable, exceptionally, of operating at 72 revolutions.

The floor of the works is 20 inches above the highest water of the Seine, and the total height of the engines above the floor reaches 40 feet. Despite this great height, the stability of all the parts leaves nothing to be desired, even at the greatest velocities. This so complete stability is due to the perfect cross bracing of the engines, to the broad calculations of all their parts, and to the system of anchoring adopted for the foundation bolts.

The distribution of steam in the small cylinders is of the patented system of G. H. Corliss, with click at the admission cut-off.

In the medium and large cylinders the distribution of the steam is assured by four cylindrical distributors of the Corliss type; but without click and without variation of expansion. All these organs of distribution operate with remarkable smoothness, notwithstanding that the dimensions are larger than ordinary, and the relatively great velocity with which they move.

The regulation of the expansion in the small cylinders is effected by hand. Independently of this, a centrifugal regulator prevents any acceleration of the velocity beyond 72 revolutions, and, in order to prevent all excessive strain of the parts in case of an abnormal elevation of the pressure of the air, a special regulator reduces the velocity of the engines as soon as such pressure exceeds 17 lb. These three methods of regulation, which are independent of one another, act upon the same expansion apparatus.

The eccentrics that control the distribution cut-offs and the cams that actuate the valves and clacks of the compressors are arranged upon a special shaft actuated by the driving shaft by means of two vertical shafts and a play of gear wheels.

Each engine is provided with two fly wheels keyed upon the coupling disks of the driving shafts. The driving shafts of the four engines are arranged in the prolongation of each other, and the frames that support the steam cylinders and the compressors and that carry the crosshead guides of the pistons are united by strong hollow cast iron cross braces. Three platforms, one above the other, of perforated iron plate, supported by polished steel columns, provided with hand rails and communicating by iron plate stairways, extend the entire length of the four engines and permit of reaching all parts of the mechanism.

The condensers, air pumps, feed pumps and purge pumps are, as a whole, very happily arranged beneath the floor of the engines in a cellar 12 feet in depth, very accessible and perfectly lighted.

Each engine is provided with a condenser, placed to the right of the large steam cylinder, and two vertical, simple-acting air pumps, controlled by cast iron working beams, connected with the piston heads of the small and medium cylinders.

The feed and purge pumps are arranged upon the air pumps, and are actuated by the crossheads of the piston rods of the latter.

Bronze valves and rubber clacks are arranged in the valve chambers of the compressors, for the entrance and exit of the air. These valves and clacks, which open freely under the action of the difference of the air pressures, are closed mechanically in order to prevent shocks.

Two of the three compressing cylinders suck up the external air and force it into an intermediate reservoir of iron plate, arranged parallel with the engines, and supported by high cast iron columns. The third cylinder sucks the air from the intermediate reservoir, in order to complete the compression of it, and forces it into the principal reservoirs of the works.

The external air is sucked through the small lanterns of the roofing, which communicate, through the trusses and the hollow pillars that support them, with the low pressure compressors.

Special pumps, of the Riedler type, independent of the large engines, furnish the water of injection of the compressors for the refrigeration of the air, which is effected in each of the compressors and in the intermediate reservoirs.

The first engine was elaborated and constructed in less than a year.

The total weight of the four engines is 3,960,000 lb. The large steam cylinders weigh 66,000 lb., and a special truck had to be sent to Paris, by Messrs. Schneider & Co., for the removal of these pieces from the railway station to the works.

All the large castings and the steam cylinders were mounted on the ground.

The driving shafts, the connecting rods, the piston rods, and all the pieces of mechanism in general, are of Creusot soft steel, of superior quality. All the axles and the hoops of the distributing motion are of Creusot special soft steel, cemented and tempered.

Fig. 1.

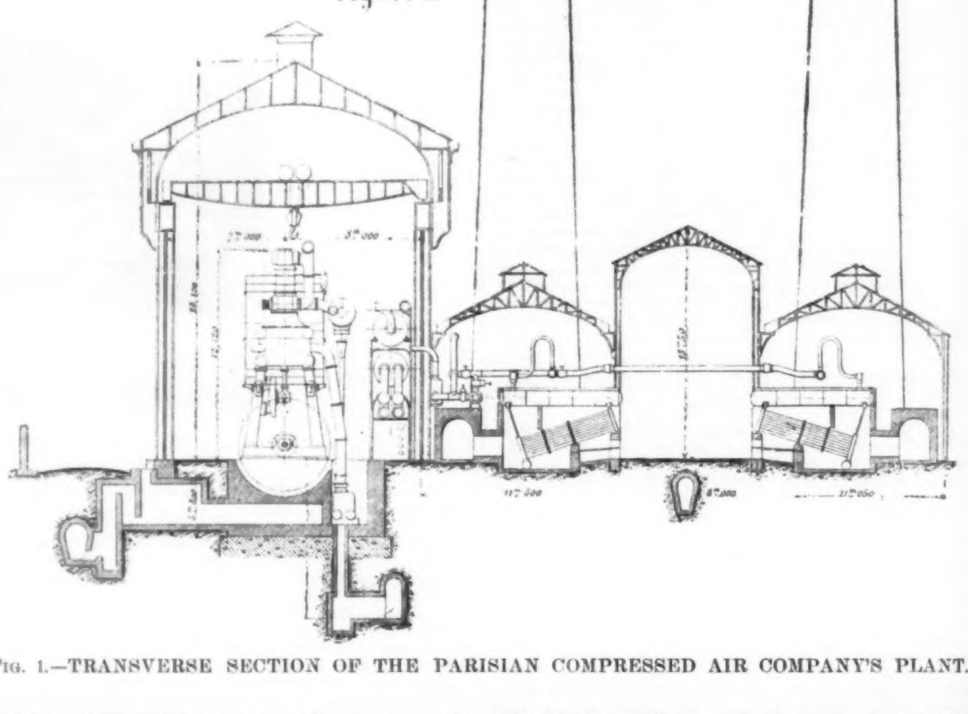


FIG. 1.—TRANSVERSE SECTION OF THE PARISIAN COMPRESSED AIR COMPANY'S PLANT.

Fig 2

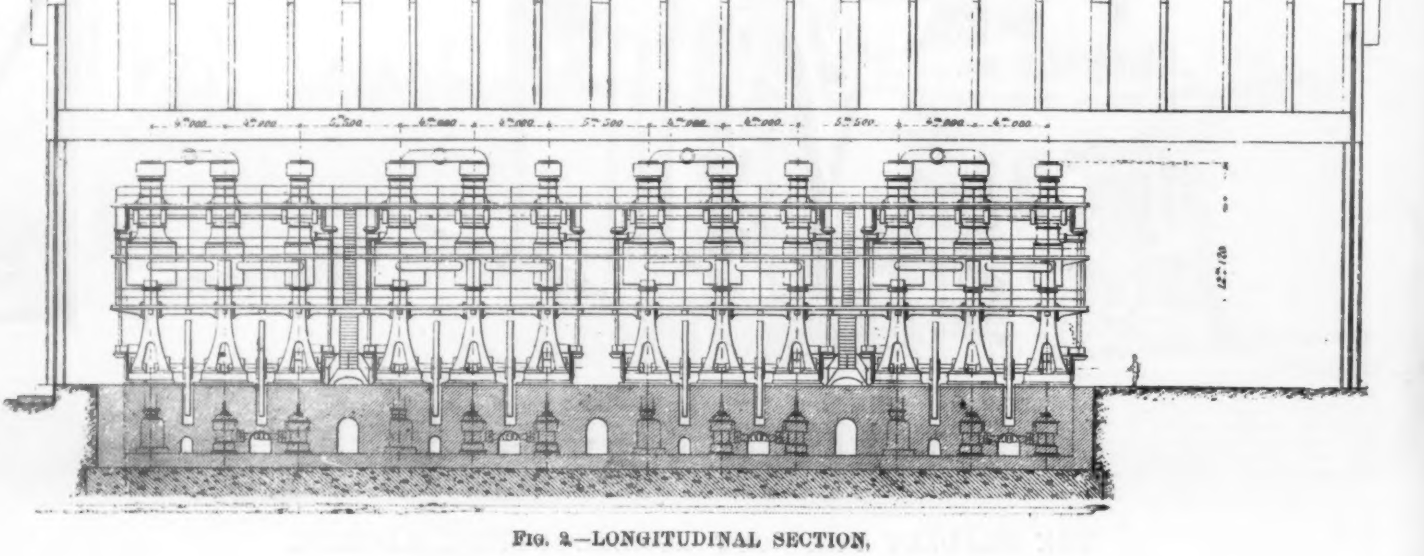


FIG. 2.—LONGITUDINAL SECTION.

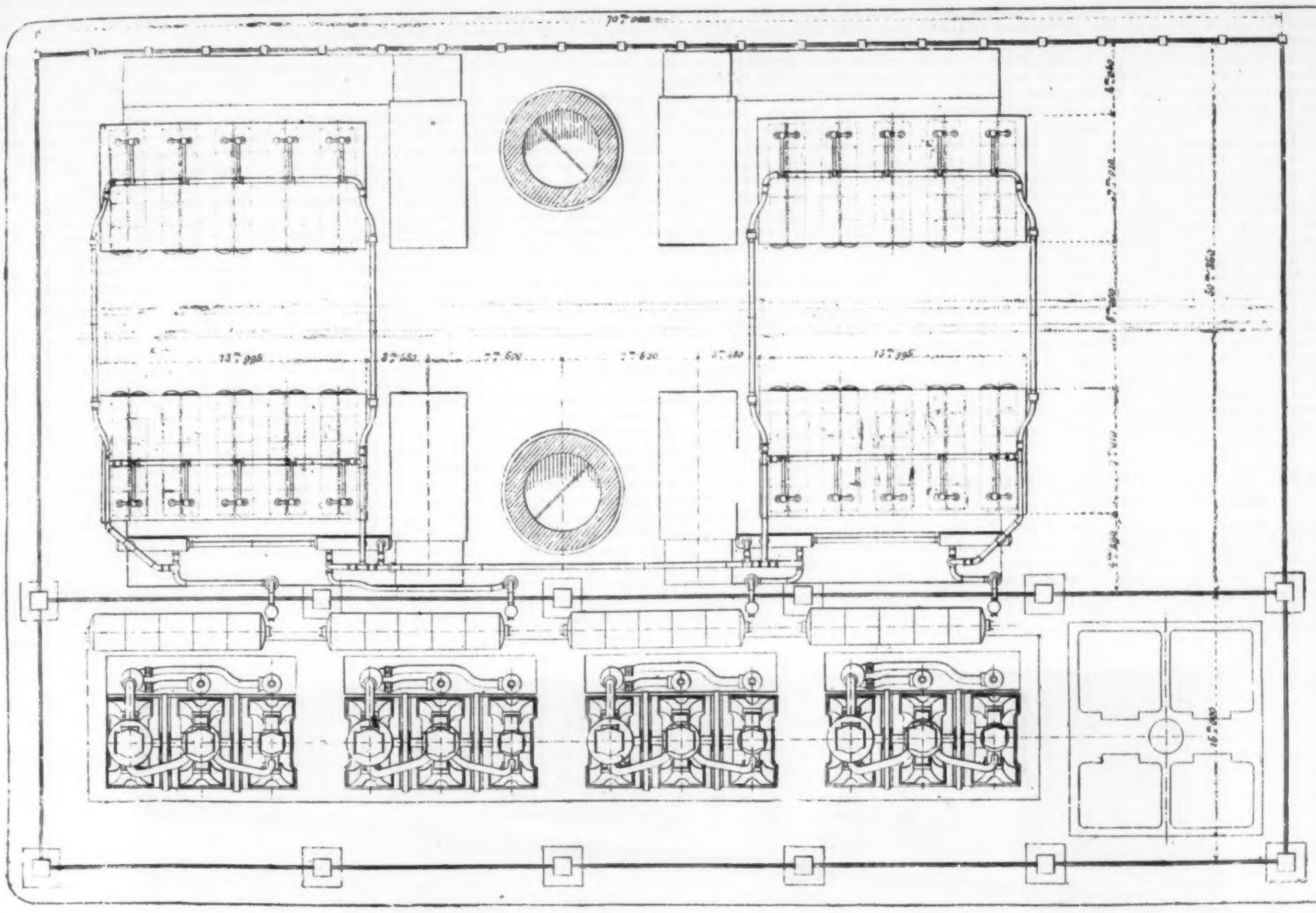


FIG. 3.—PLAN.

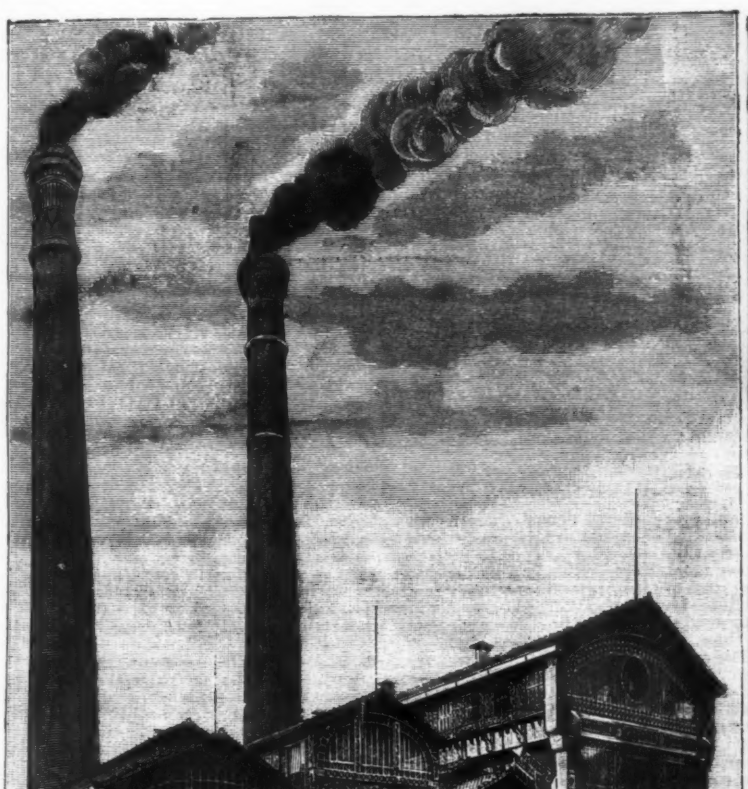


FIG. 4.—EXTERNAL VIEW OF THE WORKS OF THE PARISIAN COMPRESSED AIR COMPANY.

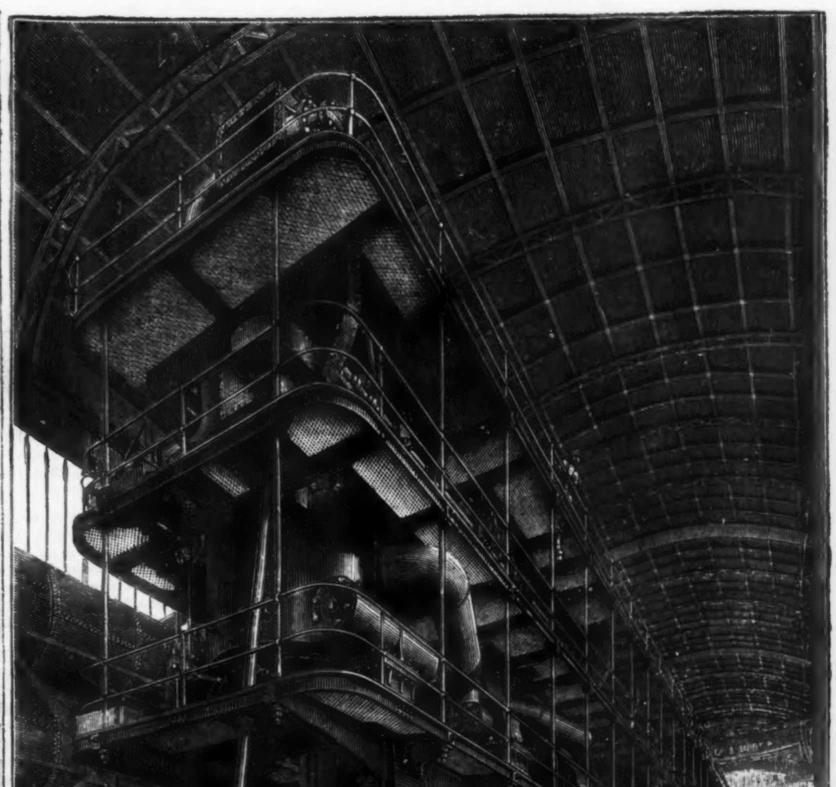


FIG. 5.—GENERAL VIEW OF THE ENGINES.

These apparatus were put in service without accidents, without any heating of the parts, and without the necessity of any retouching or modification. Such a result does honor to the great establishment which set up these engines, and testifies once again to the exceptional care bestowed by Messrs. Schneider & Co. on the study and execution of the apparatus that are ordered of them.

The Parisian Company rightly understood that in order to assure a public service as important as that of compressed air, and to attain a satisfactory exploitation, it was necessary before all to seek the guarantees that a first-class construction calls for. Messrs. Schneider & Co. undertook to realize a maximum consumption of 1¼ lb. of coal per horse and per hour. Some preliminary experiments on the consumption of fuel were made at the time that the engines were set in operation, under the direction of Mr. Meeker, inspector of the engines of the City of Paris, and under the control of Mr. Humblot, inspector general of bridges and roads. The results of these experiments were such that it is now certain that in normal operation the figure of consumption guaranteed by Creusot will not be reached.

We intend to publish, later on, the results of the official experiments that are to take place in a few months.—*Le Genie Civil.*

FIG. 6.—THE BOILER ROOM.

GROWTH OF THE THOMSON-HOUSTON ELECTRIC COMPANY.

AT the recent anniversary banquet of the Thomson Scientific Club, Supt. E. W. Rice, Jr., was one of the after-dinner speakers, and his contribution to the feast was very rich indeed, both in humorous reminiscences and statistics of the wonderful growth of the Thomson-Houston Company.

The superintendent remarked that he was one of the early employes and was the first expert. That was in the days when the works were primitive and infantile, and the length and breadth of the Nutmeg State held no more doubtful enterprise. One of his first duties was to wipe off the grease from a new machine received at the factory, and the next important task was to whitewash Prof. Thomson's office. Afterward he resumed the employment of wiping grease, and meanwhile acquired an easy familiarity with the most approved methods of killing time.

"I remember one occasion," said Mr. Rice, "when we were working nights, as men will do when business is slack, and we felt the need of a light lunch. Prof. Thomson was there, and all we had to eat was some raw oysters. The professor objected to eating raw oysters. It was easy to cook them over a Bunsen burner, but we had no butter. Here was an opportunity for inventive suggestion, and the professor was equal to the occasion. A barrel of fine white paraffine was at hand and we made a substitute of it for butter.

"It went very well," said the superintendent, smiling at the recollection, "but it did have a certain candle power to its flavor."

After two years there was a selling out to a syndicate, and when Mr. Coffin made the acquaintance of the struggling enterprise there were not above 90 men employed. In 1885, when Mr. Rice became superintendent, the number had increased to 140. The superintendent modestly alluded to the fact that the present roll at the works exceeds 3,800 names, and facilities were to be enlarged at a very early date.

Looking over the shipments for one week, ending May 7, the figures were remarkable. The combined power apparatus sent out was over 5,000,000 watts, or 7,000 horse power. The amount of material employed during one year was another stupendous item. Of iron of all kinds, 18,000,000 pounds were used, at a cost of $500,000. Of copper, 6,000,000 pounds, worth $1,000,000. Of brass, 2,000,000 pounds, worth $320,000. The pay roll was $1,600,000. Total purchases of material equaled $3,500,000. The output of the factories for one year was about 2,000 car loads, at 20,000 pounds to the car, enough to make up 100 full trains. The pay roll is now $44,000 per week—it requires $75,000 a month to run the factories.

Illustrating the rapid growth of railroad work, these are the figures: 92,000 horse power developed in motors up to the present time; 5,000 in one week of the month of May. Yet with the capacity of the works it would take only nine months to duplicate all power put out. In January, 1890, there were 80 railway companies using electricity; in January, 1892, there were 204, using 2,769 cars, with 2,363 miles of track. Since the beginning of railroad work 243 companies have equipped 4,569 cars and 2,636 miles of track.

The business done in 1883, when the Lynn management took control, was $426,000. It was $10,304,000 in the latest fiscal year.—*Lynn Item.*

CARBORUNDUM.*

THE molecular bombardment that occurs with currents of high frequency is so severe that Tesla had to go through a long course of experiments in order to discover a button of sufficient stability to stand the strain. He says: Of all the bodies tried there were two which withstood best—diamond and carborundum. These two showed up about equally, but the latter was preferable, for many reasons. "As it is more than likely that this body is not generally known, I will venture to call your attention to it. It has been recently produced by Mr. E. G. Acheson, of Monongahela City, Pa., U. S. A. It is intended to replace ordinary diamond powder for polishing precious stones, etc., and I have been informed that it accomplishes this object quite successfully. Carborundum can be obtained in two forms—in the form of "crystals" and of powder. The former appear to the naked eye dark colored, but are very brilliant; the latter is of nearly the same color as ordinary diamond powder, but very much finer. When viewed under a microscope the samples of crystal given me did not appear to have any definite form, but rather resembled pieces of broken-up egg coal of fine quality. The majority were opaque, but there are some which are transparent and colored. The crystals are a kind of carbon containing some impurities; they are extremely hard and withstand for a long time even an oxygen blast. When the blast is directed against them they at first form a cake of some compactness, probably in consequence of the fusion of impurities they contain. The mass withstands for a very long time the blast without further fusion; but a slow carrying off or burning occurs, and, finally, a small quantity of a glass-like residue is left, which, I suppose, is melted alumina. When compressed strongly they conduct very well, but not as well as ordinary carbon. The powder which is obtained from the crystals in some way is practically non-conducting. It affords a magnificent polishing material for stones.

Having found carborundum, Tesla proceeded to test it with the same tenacity of purpose and hopefulness that Edison brought to bear on his experiments with the bamboo fiber that eventually gave the ideal filament for his incandescent lamp. After various tests with the crystals he turned his attention to the powder, which he made into a thick paint with tar. Through this he passed a lamp filament, rubbing off most of the mixture afterward with a piece of chamois leather. He then held it over a hot plate until the tar evaporated and the coating became firm. This process was repeated until a certain thickness of coating was obtained, and on the point of the coated filament he formed the button in the same manner. He is of the opinion that such a button of carborundum, properly prepared under great pressure, will withstand the effect of the bombardment fully as well as anything heretofore known.

The only difficulty is that the binding material gives way, and the carborundum is slowly thrown off after some time. This single objection, however, is likely to be soon overcome. Finding that it did not blacken the globe in the least, Tesla suggested its use for coating the filaments of ordinary incandescent lamps, and he thinks it even possible to produce thin threads or sticks of carborundum which will replace the ordinary filaments in an incandescent lamp. He found the carborundum coating more durable than other coatings, not only because the carborundum can withstand high degrees of heat, but also because it seems to unite with the carbon better than any other material yet tried. A coating of zirconia or any other oxide, for instance, is far more quickly destroyed.

Buttons of diamond dust were next prepared in the same way as those of carborundum, which they approached very nearly in the matter of durability; but their binding paste gave way comparatively soon, owing, possibly, to the size and irregularity of the grains of the diamonds. Tesla then passes on to the consideration of an important point in the determination of the future utilization of the material of whose possibilities he has formed such a high estimate—its phosphorescing qualities. But he first asks the question: Can a conductor phosphoresce? What is there in such a body as a metal, for instance, that would deprive it of the quality of phosphorescence, unless it is that property which characterizes it as a conductor? For it is a fact that most of the phosphorescent bodies lose that quality when they are sufficiently heated to become more or less conducting. Then, if a metal be in a large measure, or perhaps entirely, deprived of that property, it should be capable of phosphorescence.

"Therefore," he says, and investigations made subsequent to the expression of the surmise indicate that he was guided by a true prophetic instinct, "it is quite possible that at some extremely high frequency, when behaving practically as a non-conductor, a metal or any other conductor might exhibit the quality of phosphorescence, even though it be entirely incapable of phosphorescing under the impact of a low frequency discharge."

In connection with this, Tesla offers a passing glimpse of a kaleidoscope, in which the characteristics of alternate currents or electrical impulses make fascinating and bewildering changes and combinations. He says: "By their help we may cause a body to emit more light, while at a certain mean temperature, than it would emit if brought to that temperature by a steady supply; and, again, we may bring a body to a point of fusion and cause it to emit less light than when fused by the application of energy in ordinary ways. It all depends on how we supply the energy, and what kind of vibrations we set up. In one case the vibrations are more, in the other less, adapted to affect our sense of vision." One cannot but be struck with the modesty of the distinguished inventor; he speaks of his discoveries as if they were mere matters of passing interest, instead of facts pregnant with a century of progress.

Reverting to the tests for phosphorescence in carborundum, Tesla states that when a single electrode consisting of a metal disk is covered with carborundum crystals, the electrode is covered with an intense film of the whiteness of snow. This was found to be merely an effect of the bright surface of the crystals, for when an aluminum electrode was highly polished it exhibited more or less the same phenomenon.

He says his experiments with the samples of crystals obtained were made "principally because it would have been of special interest to find that they are capable of phosphorescence, on account of their being conducting. I could not produce phosphorescence distinctly, but I must remark that a decisive opinion cannot be formed until other experimenters have gone over the same ground."

* George Heli Guy in the *Pittsburg Dispatch.*

He speaks with the same degree of reservation of the tests with the powder. He found it would not phosphoresce, but says: "Still the tests with the powder are not conclusive, because powdered carborundum probably does not behave like a phosphorescent sulphide, for example, which could be finely powdered without impairing the phosphorescence, but rather like powdered ruby or diamond; and, therefore, it would be necessary, in order to make a decisive test, to obtain it in a large lump and polish up the surface."

Here again he shows the prescient instinct of the true scientist. As a matter of fact, the phosphorescence of the later forms of carborundum, *i. e.*, those manufactured some months after Tesla's samples, is now beyond question. The discovery of a material which meets the requirements on which such important and far-reaching issues depend is destined to mark an epoch in the history of electric lighting.

Thus, much of the electrical utilization of the new product to which universal attention has been drawn by the distinction conferred upon it by Tesla's investigation into the nature and qualities of this interesting material lead to the belief that eventually its greatest utilization will be in industries other than electrical. Its later form has the appearance of a greenish yellow, glistening, cindery mass. Under the microscope the crystals are found to be transparent. Some are green, others yellow, blue, or black, and the refractive power of the whole is so great that the substance is of dazzling beauty. Its general formation is somewhat irregular, more or less resembling bort, or diamond powder, and the facets of its crystals are, as a rule, convex.

Its characteristics are extreme hardness, refractive power, insolubility, and infusibility, and especially its high abrasive power. Its manufacture is in such an early stage that it is impossible yet to say where its greatest use will be found. It will unquestionably, however, be in demand by diamond cutters, lapidaries, and jewelers, dentists, valve grinders, and for brass and optical work; in fact, in all industries where abraders are used in the form of either diamond powder or emery. The cost of its production is so low that the manufacturing industries will find themselves supplied with an abrasive material of the hardness of diamond powder and the general adaptability of emery powder, at a price relatively but little higher than that of emery, and practically much less.

A very interesting and conclusive test of its relative abrading power was made before the writer. On the end of one of two strips of glass, about 1 inch wide by 2½ inches long, was placed a quantity of fine emery powder, which had been moistened with water. The second piece of glass was then superposed on the first, and at a given signal the two were vigorously rubbed together under pressure for 15 seconds. The emery was then washed off, and a corresponding quantity of carborundum powder of the same degree of fineness was placed on the other end of the glass, and the test was repeated for the same space of time. The difference in the sound of the action of the two powders was at once apparent, the carborundum seeming to have at least twice the grip of the emery. On looking at the record of the respective work on the glass, this impression was more than verified; the emery had made a slight irregular cloudiness on the glass, but the carborundum had rendered it opaque, and had cut a well defined path across it. The cut only hints at the effect produced.

The crystals of carborundum are so hard that it is found impossible to reduce them to a powder by any grinding process. So a crushing force, such as is obtained in a stamping mill, is resorted to. To grade off the powder in the different degrees of fineness, the crushed product is mixed with water and permitted to float for any required length of time, and then run off and allowed to settle in tanks. The coarseness or fineness of the powder is determined by the length of time allowed before running off.

In this way the grading can be most accurately effected. The time allowed varies from four minutes in the coarse grades to two hours for the exceedingly fine ones. The crude material is made directly into wheels for machine shops. The abrading power of these wheels, judging by tests lately made, will bring them immediately into active competition with emery wheels. One of our prominent manufacturers, in discussing recently the chances of successful rivalry with emery, said: "The field is large. Pittsburg alone uses $50,000 of emery wheels yearly, and the annual consumption of these wheels throughout the United States is at least $2,500,000."

The economy of carborundum will be seen in the fact that it will do 25 per cent. more work in the same length of time, and the class of labor employed in the use of these wheels is very expensive, running up to $4 a day. The saving, therefore, will be threefold—in labor, time, and efficiency. In all probability the finer grades of carborundum will be used with cloth and paper, as emery powder now is. A short time ago some carborundum was submitted to a plate glass manufacturer. Testing the material in his office he decided it was too soft, but he afterward found when trying it in the factory it was too hard, and for this reason:

The finishing process of plate glass is started with sand, and then a coarse grade of emery powder is used. In the course of pressure and abrasion the emery particles break down, and become so reduced as to leave the glass in a high state of finish. The carborundum would not break down, but left the glass finished in a degree represented only by its original fineness, and the conservative glass finisher declined to countenance such a sweeping innovation, even though promised a powder of any degree of fineness he wished.

In the grinding of valves and cocks, the present practice of using a coarse emery powder to begin with causes grooves to be left in the metal, and these have to be taken out by a second process. The actual cost of the emery is a small part of the total expense of the process. A man receiving $3 a day will scarcely use a pound of emery in two weeks. With carborundum this process can be carried out at the first intention, and with an efficiency of 50 per cent. in excess of the old process. Beyond this it enables the manufacturer to turn out a class of work the cost of producing which by the ordinary emery method would be prohibitive.

One of the most effective uses of carborundum will be in the construction of points for dental engines for the excavation and grinding down of teeth. These points are already made in various sizes, and are commended by dentists with enthusiasm, and declared to be, when properly bound, equal in every respect to diamond wheels. The diamond wheel is a disk of copper charged with diamond powder, and when used it has to be kept continually wet. Another disadvantage is that as the fineness of polish produced on a tooth increases, the effectiveness of the abrading surface decreases, and the expenditure of additional time and labor becomes necessary.

The difference between the ordinary and the carborundum point was shown recently in a dentist's parlor in New York, where the dentist quietly substituted the latter for the former. The patient instantly noticed the change, and described it as the difference between "clean cutting and jagged sawing." Most people have had their share of bad quarters of an hour with the dentist, and have a vivid recollection of the sickening vibration of the cutting wheel. It is comforting to know that this form of martyrdom can now be banished. As showing to what extent small units

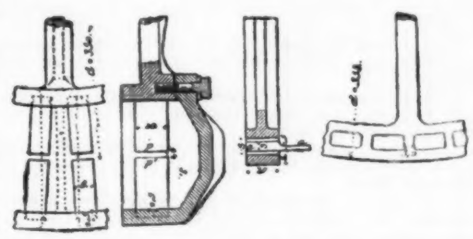


FIG. 2.—DETAILS OF ROTATING FIELD MAGNET AND OF FIXED ARMATURE OF PATIN 40 KILOWATT ALTERNATOR.

grow into big industries, it may be stated here that there are 25,000 dentists in this country, each of whom uses on an average $10 worth of wheels a year, representing an expenditure of $250,000.

For the cutting of rock crystals for lenses, tests have shown carborundum to be especially effective, and for this purpose it is likely to completely supersede emery, which is now used. A singular characteristic of carborundum is that its abrasive power is increased in proportion to the hardness of the material operated upon. For instance, while in lead plate cutting it would show no higher in efficiency than emery, in treating chilled iron or steel its superiority would be markedly manifest.

Of course the main interest of carborundum to the scientist will be centered on its newly found adaptability to the purposes of a wonderful discovery, and more especially will this be the case when crystals large enough to form an entire button are produced, which is easily conceivable. But enough has been said to justify its claim to be considered one of the most remarkable commercial products of recent years, and one which will effect a revolution in a large number of industrial fields.

THE PATIN ALTERNATOR.

THIS high pressure alternate current machine recalls at first glance, says *L'Industrie Electrique*, the dynamo designed some ten years ago by M. Anatole Gerard; a machine which stopped at the projected stage, the need for large output alternators not being felt at that date. There are, however, in reality several points of difference. M. Patin's machine has rotating field magnets and a fixed armature. It takes the place of a steam engine fly-wheel, or it can be mounted direct on to the shaft of a turbine. This new arrangement has the double advantage of doing away with rope or belt transmission, which absorbs mechanical power and demands constant attention, and of reducing to a large extent the space occupied by machinery. Until now all direct-coupled machines demanded angular velocities which rendered necessary a recourse to high-speed steam engines, consuming a great deal of steam, and quickly wearing out. M. Patin's dynamo has been designed for coupling direct to Corliss engines or others of the same type, having a high efficiency and a small angular velocity.

The rotating field magnet is mounted on the engine shaft and acts as its fly-wheel. It consists of two cast-iron rings (see Fig. 1) carrying soft iron pole pieces recessed into it. The inner ring forms part of the fly-wheel itself, and the outer ring is joined to it by means of special arms as shown in Fig. 2. The fixed armature can be moved laterally for examining and quickly replacing coils in case of accident. The armature coils, which are composed of flat strips of copper and are wound on a frame of cast copper, have an arched shape like the annular cylindrical space in which they are fixed. They are kept in position by bronze stirrups, bedded in the armature core with a special cement.

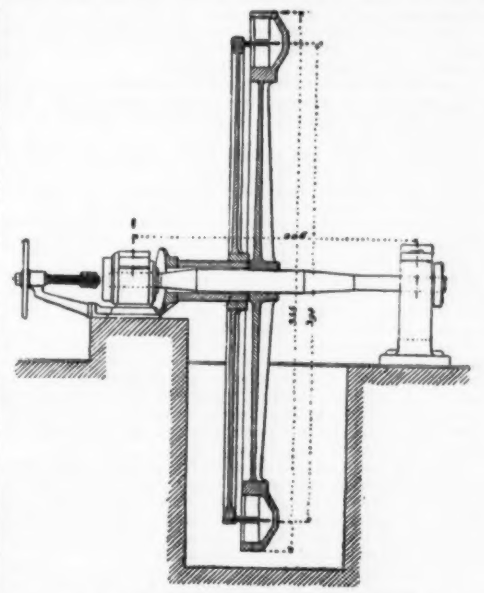


FIG. 3.—CROSS SECTION OF PATIN 40 KILOWATT ARMATURE.

(Fig. 2.) The displacement of the armature is effected by means of a screw actuated by a hand wheel placed near a bracket, and communicating its motion to two cross pieces, which are solid with the armature core. Two insulated copper rings mounted on the dynamo spindle are connected up to the ends of the field magnet coils; the exciting current from a special dynamo (sometimes distinct, sometimes arranged on a prolongation of the shaft) being brought to the rings through two rubbing contacts.

Figs. 2 and 3 relate to a 40-kilowatt machine. Fig. 1 is a perspective view of a 75-kilowatt alternator, of which the following are the principal data:

Number of field magnet poles	76.
Electromotive force	2,400 volts.
Current	31 amperes.
*Peripheral speed	14·66 meters per second.
Armature resistance	0·75 ohm.
Length of wire on armature	520 meters.
Section	3 sq. mm.
Excitation losses	2,500 watts.
Armature losses	730 watts.
Electrical efficiency	96 per cent.

* 2,886 ft. per minute.

The arrangements adopted by M. Patin in his new alternator commend themselves to us, says *L'Industrie Electrique*, owing to the ease with which the armature can be repaired and the simplification of its construction brought about by its being fixed. Let us hope that practical experience will confirm this favorable impression.—*The Electrician.*

FIG. 1.—PATIN 75 KILOWATT ALTERNATOR.

CLARIFICATION OF SUGAR CANE JUICES.*

By E. W. DEEMING.

THE solids not sugar found in all saccharine solutions obtained from sugar cane and sorghum exert a marked influence upon the granulation of the sucrose proportionate to the ratios of the former to the latter.

The solids not sugar carried with the juice into the sirup and finally into the masse cuite are responsible mainly for the inferior color of the sugar, the other elements affecting the color of the sugar being caused by the excessive use of lime or the caramelizing of the glucose during film evaporation.

We cannot as yet in a practical manner remove or destroy the glucose, thereby avoiding the production of molasses, which carries with it all the sugar it can dissolve. The ratio of sucrose to glucose is therefore practically fixed. All our attempts to improve the juice are therefore restricted to the removal of the solids not sugar which restrain granulation and deteriorate the quality of the sugar.

The clarification of cane juices is or should be the result of three operations: application of heat, application of chemicals, and filtration.

Heat checks fermentation and evaporates acids which hold albuminous matters in solution, coagulating and rendering them insoluble. Heat is most valuable as an aid to chemical action.

Chemicals used are slaked lime, sulphate of lime, sulphurous and phosphoric acids.

The use of slaked lime aids coagulation of impurities by the formation of insoluble lime compounds.

Sulphurous acid prevents fermentation, decolorizes and by some claimed to aid in coagulating albuminous matter not affected by heat.

Phosphoric acid, in conjunction with lime, forms a precipitate of phosphate of lime, improving the color and the facility with which it may be filtered. Phosphoric acid should be quite pure.

The now prevailing method of clarification is the use of clarifiers, well known to you all. We are aware that, practically, the present system of clarification has prevailed since the earliest recorded instance of the production of sugar from sugar cane. Is it possible that there can be no improvement in this most important feature of sugar house work?

Chemists have sought in vain for a compound that would practically place the impurities in a condition rendering their separation and removal possible, and there are now offered planters' "compounds," so-called aids to clarification, whose values, if they possess any, are so slight as to fail of appreciation.

We are therefore back again to heat, aided by the single element, lime, as practiced by the earliest sugar makers.

By the use of our clarifiers, the juice, after a previous treatment of lime and possibly sulphur, is heated slowly to the atmospheric boiling point, 212° Fahrenheit. This heat, aided by lime, causes the coagulation of certain impurities which, being of less specific gravity than the juice, rise to the surface; others of greater specific gravity are precipitated; others, and they form a large proportion, are held in suspension as a minute flocculent matter which is precipitated slowly and scarcely within the necessary limit of time possible to preserve juices against fermentation or serious deterioration.

They are necessarily carried on through the different manipulations to the final products, where they restrain granulation, discolor the sugar, and darken the molasses.

The injurious action of this light flocculent matter is greater with multiple effect evaporation than with steam trains. This statement is based upon the fact that other conditions, unchanged steam trains, with our present system of clarification, make a better quality of sugar.

The explanation of this lies in the fact that a temperature of 212° F. does not coagulate or otherwise affect as large a proportion of the impurities as a temperature of 228° F., as attained in concentrating the juice to a 28° Baume sirup in an open evaporator. In other words, a saccharine solution heated to 228° F. has its impurities so changed in their characteristics as to permit a more complete separation of impurities than is possible at a temperature of 212° F., which means an improved coefficient of purity and a better quality of sugar.

The test of a clarified juice as made at present is indicated by the presence or absence of this light flocculent matter, as observed in a test tube or bottle, which is considered satisfactory if the juice is clear and this matter appears to be settling.

This desired condition of the juice is secured by heat and the use of lime; the best results of such clarification, as judged by the eye and determined by its purity, and the poorest results, as regards the quality of the sugar produced, follows the use of a slight excess of lime.

It is asserted that clarification by present methods would be much improved if the impurities rising to the surface were not brushed therefrom, but beaten into the juice. When completely covered by the juice they settle rapidly, attaching to themselves much of the light flocculent matter held in suspension, causing a more complete and speedy separation of the impurities than now prevails where the scums are removed from the surface.

It cannot be denied that lime darkens all products in proportion as it is used, regardless of the acidity present, which it is calculated to correct. This statement is confirmed amply and fully by the practice of making molasses from sorghum, where the slightest addition of lime makes a perceptible difference in the color of the product. It likewise makes a change in the sweetening power, the unlimed product when used for cooking purposes requiring nearly as much sugar for sweetening as if none were employed.

Lime becomes more active or effective as the solutions containing it are increased in temperature. A neutral clarification at a temperature of 100° F. is an alkaline solution at 212° F., and at 228° F. will be much darker than that due to concentration only.

It is well known that an excess of lime in cane juice will redissolve impurities already set by the combined action of lime and heat. Dr. W. C. Stubbs has shown that the excess of lime above what is required to neutralize the free vegetable acids of the juice will combine with the glucose, forming minute black specks held in suspension and impossible of removal by any known process.

They may be in sufficient quantities to darken the entire sugar house products. To secure a bright molasses, lime must be used moderately and a light sugar can only be produced from a light sirup.

The operation of tempering cane juice with lime is one of extreme delicacy and should be placed in skillful hands. The presence of glucose and organic compounds in Louisiana cane juice, upon which lime acts with such disastrous results, precludes the possibility of working alkaline juices to the slightest degree and later precipitating the lime as by the carbonatation process as practiced with beet juice.

The writer recently asked an old time head clarifier man working on a four million pound crop if he ever used litmus paper; he replied he had never seen any, but heard of a man on Lafourche who used it. The latter's work could hardly have been inferior to that of the former.

Large white crystals, once famous as a production of Demerara, were produced from juice tempered with extreme care, using lime water instead of cream of lime, density being 10° B., not 17° B., and preference being given to rain water for slaking and applying the lime.

An excess of lime produces invariably a sugar having a grayish tinge, and no amount of sulphur fumes can remove it.

Acid juices cause an inversion of sugar. The color may be better, but this advantage is offset by the diminished quantity secured.

Acid juices produce a fine soft grain of sugar, difficult to purge in the centrifugal and easily dissolved by the wash water.

It is claimed albuminoids are set only in a neutral solution—one neither acid nor alkaline; and they are again redissolved, taken into solution, should the juice become acid or alkaline.

We can scarcely conceive of a chemical action or change occurring in a boiling solution of pure sugar and water. A sugar solution containing acid or alkali, especially if containing organic matter, could not escape some change.

In the open evaporation of 228° F., lime present becomes more active, and will coagulate impurities, mainly coloring matter not acted on by a lesser degree of heat, which accounts for the superior product of this evaporation.

The heavy incrustation of scale on the coils of the open evaporator, much greater than is found on the heating surface of multiple effects, is caused by the higher heat of the former, rendering insoluble material not affected by the lesser heat of the latter, which is additional confirmation of the statement that each additional degree of heat added to these solutions renders insoluble matter not so affected by a previous or less degree of heat.

In multiple effects, juice will enter the first effect at a temperature of 180° F. and leaves the second effect at a temperature of 140° F. At no time will the temperature equal that of the clarifiers, 212° F., and such matter as the latter temperature failed to set is carried on into the final products.

The organic matter, as found in cane juices, consists of coloring and other matters of an albuminous nature similar to the white of an egg.

Heat coagulates the albuminoid, which envelops and precipitates other matter, its effect being similar to the use of eggs in preparing coffee, made by boiling a well beaten egg and coffee in water, or by the use of dried blood for clarifying solutions in refinery practice.

The albuminoids in cane juice are in small quantity and less pure than is found in dried blood. In a pure state they coagulate at 176° Fah. As found in cane juice, coagulation continues until a finish (open strike pan) at 241° Fah. has been reached.

The practice of heating slowly the contents of a clarifier—a necessity, of course, because of its large size and limited heating surface—causes the impurities to coagulate slowly, and in very minute particles, as evidenced by the fact that some are of less specific gravity than the juice and others are held in suspension.

The juice should be heated to the boiling point, instantaneously causing the coagulation of the impurities in larger, firmer particles, which would be precipitated immediately the juice was allowed to rest.

An egg broken in cold water and the latter brought to a boil would cause the albumen to coagulate in fine particles—a broken egg dropped into water at the boiling point is immediately coagulated in one solid piece.

Sorghum juice placed in a closed cylinder and heated to 240° F. at a pressure of twenty-five pounds per square inch will, upon cooling, have its impurities precipitated at the bottom in one lump, as a poached egg.

Most of the points thus far stated are facts, confirmed by actual sugar house practice, and a careful consideration of those points most essential for good clarification suggests the following practice as a means of improving the present system of clarification.

First—The use of the minimum amount of lime.

Second—The instantaneous application of heat up to 230° or 240° F. under pressure in closed vessels or pipes.

Third—Filtering the entire juice by means of pressure filters.

This is not a scientific treatment of this subject, but a mere statement of sugar house practice by one who has wrestled with sorghum juices and is familiar with the methods employed for cleaning cane juice, and who is interested in the introduction of a process of clarification which contemplates filtering continuously all the juices by wholly dispensing with the use of open clarifiers or tanks.

By this process the juice is taken to the sulphur box, if one is used, then by an open trough leading over a juice tank divided into three compartments; a "4" opening in the bottom of this trough, and controlled by a wooden plug, directs the juice into either of the three compartments. The compartments are each four feet square and hold about 470 gallons, one compartment being filled each ten minutes if working 300 tons per day.

A 1-inch water glass 16 inches long, upper end open, is placed on each compartment; into this fills from the bottom the juice free from trash and foam. The exact contents of the tank are indicated by a graduated scale back of the glass. The brix is taken by dropping a spindle into this glass tube, and a sample of juice is taken just below the glass.

Lime is added to the juice in this compartment. Meanwhile the second compartment is being filled, which in turn is measured, weighed, sampled and limed, while the second compartment is being pumped out and the third is being filled.

From this tank the juice is pumped into the absorber, occupying the space outside the copper tubes, thence passing into the digester, where it is heated to a temperature of 230° F., or higher if desired. It now again enters the absorber, passing through the tubes, which are surrounded by the cold juice.

The adjustment of a three-way cock directs through the absorber "en route" to the digester the amount of juice necessary to reduce the temperature of the superheated juice below the atmospheric boiling point, before it enters the filters, from which it passes to the evaporators.

By this process the juice is accurately measured without an allowance of 1 to 3 per cent. for foam or expansion of the juice due to partially heating while the clarifier is filling.

Calculating the average brix and ascertaining the weight of a gallon at that density and multiplying this by the gallons, would give net weight of juice, from which may be accurately determined the mill extraction if the weight of canes are known.

One man thus directs the juice into its proper compartment, measures, weighs, samples, limes, controls the discharge to the pump, controls the pump, controls the temperature of the clarified juice leaving the absorber and controls the initial heat employed in the digester. He is the one and only clarifier man of the house, being held responsible for these duties, which are easily within the ability of an ordinary man.

The pump employed for forcing the juices through this apparatus also serves as a filter press pump, a pipe connection being made to the presses from the apparatus; thus the pump handles only cold juice free from any gritty substances found in scums. The digester and absorber and all intermediate connections are made and tested for 100 pounds pressure, which is the practical maximum working pressure for filter presses.

The digester is made of ¼-inch boiler steel, cylindrical in form, 32 inches in diameter, and 7 feet long, with cast iron flanges at the ends, to which are bolted heavy tube plates and steam chest with covers. It is placed horizontally, and contains 116 1¼-inch diameter copper tubes, extending from head to head. The tubes are held in place and a joint made in the tube plate by a rubber gummit and not expanded, and consequently do not become loose and leak.

By removing the steam chest cover every tube may be removed, cleaned and replaced. The steam occupies the tube, the juices being outside, from which the scale is removed by the use of acid, as with clarifiers, cracking it off with dry heat, or more thoroughly between seasons by removing and scraping the tubes, it being unnecessary to remove and scrape the tubes during the working season. The discharge is an opening 10 inches wide by 5 feet long, directly in the bottom of the cylinder. Inclosing this opening is a steel hopper extending from the sides and ends of this opening to one central discharge twenty-eight inches below.

The absorber is a steel cylinder 7 feet 6 inches long, with tube plates, steam chest and covers. It is placed vertically, and contains 14 2-inch copper tubes, which are held in place by a fibrous packing, which prevents leaks and permits the removal and replacing of tubes should it be necessary.

The absorber, as its name implies, is an apparatus wherein the superheated juice from the digester is absorbed by the cold juice.

Superheat, or all above 212 Fahrenheit, which can only be imparted to these solutions under pressure, will condense immediately the pressure is removed, or it emerges into open air, flashing into steam about the filter presses. This high heat would also injure the filter cloths. By the use of the absorber the cold juice is employed to utilize this superheat which it contains entering the digester, requiring therefore less heat to secure the requisite superheat.

A dial heat gauge registers the temperature of the juice as it enters and leaves the absorber. Brass cocks and valves arranged with suitable staffs, when beyond reach, bring all valves of this apparatus within easy reach for controlling the temperature and the flow of the juice as desired.

In the digester the steam enters the top of the steam chest at one end, passing directly through the tubes, the condensation being discharged from the bottom of steam chest at the opposite end.

A 5-inch exhaust steam connection is made and a 4-inch live steam line is connected at top of the T into which the exhaust steam enters, thus enabling the use of live steam when necessary to supplement the exhaust steam by siphoning the exhaust steam into the apparatus without causing a back pressure on the exhaust steam line. Conveniently placed pressure gauges and valves within reach permit a perfect control of the pressure and heat.

The juice leaving the pump enters the absorber (such portion as is required) at the upper end, discharges at the bottom. Thus any precipitation occurring there is carried out by the discharge pipe and carried on to the digester.

The juice enters the digester at the top, midway between the ends and directly over the discharge at the bottom. This is to facilitate the precipitation of all coagulated parts directly to the discharge, that they may be removed in the order in which they enter with the juice. The arrangement of the tubes in vertical lines aids separation and precipitation, leaving practically no surfaces on which the material may lodge. It therefore enters the filter press with its own impurities—an essential condition for successful filtration.

The sugar in a neutral cane sugar solution suffers no inversion by the application of high heat. It is unaffected, as was shown by the experiments with the cyclone evaporator working under a temperature of 1,200° F. In the manufacture of sugar on some islands, water being scarce, cane juice is used in the boilers under a pressure of forty pounds and a temperature of 290° F., and the steam therefrom used in the coils of a vacuum pan. This process is reported to produce less

* A paper read before the monthly meeting of the Louisiana Sugar Planters' Association, Thursday evening, June 9, 1892.—*From the La. Planter.*

molasses than where clarified in the usual way, indicating less inversion and a higher purity.

Next to securing a neutral solution and the highest practical superheat, it is advisable to use any chemicals of whatever nature that assist in removing the solids not sugar, without combining with the sucrose, to prevent granulation or combining with the glucose, discoloring the solution.

The action of the lime increases with the temperature of the juice, and the minimum amount of lime necessary to neutralize the free vegetable acids of the juice only should be used. These conditions are possible with this process. The superheat would secure the maximum service from the minimum amount of lime and its use intelligently controlled.

Tests for acid in the superheated juice could be made when the compartment was but half empty, and, if necessary, more lime could be added, or a less amount of lime used in the next compartment.

If possible, all saccharine solutions, as obtained from sugar cane, sorghum, beets or their products, should be subjected to some form of filtration previous to final concentration. It has thus far been considered impractical to devise a filter wherein the impurities contained in the solution would form its own matrix, or filtering medium, through which the whole juices could pass.

It is also known that saccharine solutions, especially when first secured from the raw products, contain gum and mucilaginous compounds that, when subjected to a temperature of 212° F. or less, will imperviously coat the entire filtering area, rendering futile thus far all attempts at successful filtration of the raw juices.

The atmospheric boiling point, 212° F., is insufficient to produce the necessary changes in the gums and other matters that impede filtration. A much higher heat is necessary to coagulate them into a firm granular form whereby their specific gravity is greatly increased, while the specific gravity of the juice from which the impurities are taken is reduced correspondingly—a necessary condition for filtering any material.

At Calumet plantation some few years since were made extended experiments with filter presses in the effort to discover a filtering medium forming a matrix through which could be passed sugar house juices. The result was practically a failure, as was shown by the excellent report made by Mr. W. J. Thompson, under whose direction the work was done.

He states as his belief that the refractory material, the impediment to filtration, exists as an insoluble suspended impurity—in small quantity—and it is not removed by fermentation.

The cloths used in a filter press merely restrain the impurities from passing through until a filtering medium is formed of the impurities (scums), which are by the present form of clarification composed mainly of lime with albumen, cane fiber and mud.

In the present practice of filtering scums only about 10 per cent. of the juice is filtered, which should result in an easily formed, solid, dry cake, the proportion of filtering medium being large as compared with the product to be filtered; this, however, is not the fact, as many have great difficulty in securing a dry cake.

In most instances a dry cake is only secured by use in the filter press of steam at boiler pressure, which superheats the cake coagulating the gums or so changing them that more juice may follow through, bringing in more scums until the press is filled. The effect of the steam on the cake is precisely the same as occurs when the juice is superheated in the digester.

The cloths usually used on filter presses are of heavy weight, and too closely woven, offering too much resistance to the passage of the juice, especially when they are swollen with heat. They continually shrink, are difficult to wash, to dry, and liable to mould with mildew.

A cloth much lighter in body would be preferable, easily made, washed, handled and dried; would not continually shrink, would offer less resistance to the passage of the juice, and a much larger quantity of juice could be filtered in a given time.

Would recommend light-weight cloths, using two of them if necessary, only the outside one needing washing except at long intervals.

Light-weight cloths must certainly be used if any considerable portion of the whole juices are to be filtered. Two thicknesses of ordinary gunny sacking when new (later three) gave excellent results in filtering over 20,000 gallons diffusion sorghum juices in 12 hours through one press of 200 square feet of surface, after the juice was first heated to 218 or 220 degrees Fahrenheit.

After the first five minutes the juices came clear and remained so.

If perforated plates are used on filter presses, they should be well supplied with medium large openings, and their efficiency would be increased if they were corrugated or crimped vertically. Presses should also have half-inch or five-eighths-inch discharge cocks. The juice once having passed the filtering medium and the cloth should not meet with unnecessary resistance in the discharge cocks.

The impurities removed from cane juices by this process differ from those removed by the present process more in quality than in quantity; consequently a filter press capacity adequate for the scums should handle the whole juices, if the discharge cocks of the filter presses have sufficient area and heavy cloths do not unduly increase the resistance.

At no time are sugar house products in a more favorable condition for filtering than previous to concentration, provided the juice contains in a coagulated condition all the impurities likely to be set during evaporation.

As the density increases, the difference in the specific gravity of the juice and its impurities become less, and they are therefore more difficult of separation, even if it were possible to pass the concentrated juice through any form of filter.

The claim of novelty of this process consists of a process for filtering saccharine solutions by an intermittent or continuous flow of solutions which are under pressure due to heat or frictional resistance or both, with atmosphere excluded and at a temperature at or above the boiling point of the solution in open air.

It is a process for filtering saccharine solutions by the use of one or more condensers by which the superheat necessary for securing the requisite temperature for filtration may be absorbed by the cooler stream of the solution, "en route" to the heater employed, thus avoiding the loss of the superheat when the solution emerges into the open air.

Two of these machines were made last year; one for J. B. Levert, of St. John plantation, who failed to get it into position, and one for Prof. S. A. Knapp, of Huron plantation, which was placed in position, but not operated in connection with filter presses, as they were not in readiness. The crop here was small and not worked until December, when everything was sacrificed to save an already frozen crop.

Having no double effect, the exhaust steam was used in the digester, which heated the raw juice above 212 deg. F. at times, whence it was discharged into the clarifiers, which were in this instance but settling tanks. The impurities were rapidly precipitated, leaving a very clear juice, which confirms the belief that a better separation of the impurities occurs when all the scums, including those usually rising to the surface, are set and retained beneath the surface, where they envelop and attach to themselves more impurities than if allowed to rise to the surface, even if the ordinary clarifier temperature only be attained.

This apparatus can be recommended for steam train houses or those having a surplus of exhaust steam. Its large heating surface, equal to eight clarifiers, is admirably arranged for the use of a low pressure heat. A large number of short straight tubes that are easily drained of condensed water make it a desirable apparatus for utilizing a now waste heat, which, if properly applied, should do the entire clarification.

If filter presses are not used, the juice could be discharged into clarifiers or open tanks, which would be merely settling tanks.

It could also be recommended to houses short of clarifier capacity, but without filter presses. Exhaust or live steam could be used and the juice discharged into the clarifiers at or near the boiling point, so little or no steam could be used; thus their capacity would be doubled, because used only as settling tanks.

In the process of sugar manufacture there is a constant deterioration of the juice from the moment the stalk is severed from the root until it attains the sirup state. Especially is this noticeable in the juices if detained at any point in open tanks. The changes are greater before than after clarification, and less with juices limed than unlimed. The least possible time and the least possible exposure to air should intervene between the juice leaving the stalk and its conversion into a sirup.

Long exposure to air renders the juices less sensible to the action of such reagents as are employed for the clarification, and the liability of fermentation is proportionate, as the conditions are favorable as regards the temperature, previous condition of the juices in the stalk and the use or non-use of sulphur or lime as the juice is received.

Within thirty minutes after leaving the mill the juice will have been sulphured, brix taken, limed, heated to 230 deg. F., cooled to 200 deg. F., filtered and ready for the evaporators. This wholly without clarifiers or tanks, except measuring tanks, where a known quantity of juice is treated with lime.

This apparatus is especially adapted for use in plantation sugar houses—simple in construction, well made, strong, easily got at inside and outside, heating surface easily cleaned, washout arrangements complete, requires only the space occupied by two clarifiers and costs less than clarifiers having an equal heating surface.

A word upon the preparation of lime and its application to cane juice.

The lime should be slaked under water, and water added until a proper consistency for straining through a wire sieve, about 12 mesh, all lumps and unslaked pieces restrained by the screen to be rejected.

The strained portion to be placed in molasses barrels sawed in halves, where in a few hours occurs a complete separation of the lime and water. The water is removed, thrown away, or again used for slaking fresh lime, thereby saving the four per cent. of lime it holds in solution.

The thick cream of lime can be handled with a paddle, and is used by dissolving in a bucket or a half barrel with water, never juice, to a certain density Baume.

This is applied to the juice with a basin of a known capacity, by distributing it equally over the surface of the juice and immediately stirring the juice to insure its speedy distribution throughout the entire body.

Thus can a known quantity of thoroughly slaked lime be thoroughly incorporated with the juice, without injuriously affecting the juice with which it first comes in contact, and prevent, if judiciously handled, the accumulation of undissolved unslaked lime on the clarifier bottom.

Lime for use in this manner can be slaked days or weeks before needed for use. It will keep for months, if protected from sun and rain. Dry air-slaked lime, as usually employed, is not as strong as fresh lime, and those portions longest exposed have less strength and are soonest slaked, when applied to juice, except when fully air-slaked, when it and the unslaked portion fall to the bottom, where it slakes slowly or not at all.

Unless provision is made for the action of the unslaked portion during the heating of the juice or later in the scums an alkaline juice will certainly follow. The unslaked lime in the scums, hard as stone itself, seriously cuts the linings and packing of filter press pumps.

We frequently see very dark juices from the filter presses with a strong smell of lime, due to lime slaking in the settlings after they leave the clarifier.

Juice, when used to slake lime, is burned, as it were, by the excess, and the injury cannot be corrected by adding it to the clarifier; the same injurious action occurs, but to a less extent, when dry lime is added directly to the juice in the clarifier.

Impurities are easiest separated from juices where they are heated, while neutral—neither acid nor alkaline.

Impurities set in a neutral juice are redissolved and again taken into solution impossible of removal, should the juice become alkaline by the lime slaking during the process of clarification.

It is, therefore, essential that the application of lime be placed in skillful hands, if you would secure a good clarification and preserve the color of the sugar.

The advantages of this process of clarification are:
Clarification is continuous.
Without exposure to air.
Minimum heat required.
Whole juices filtered.
Minimum discolor of juice.
Maximum effect of lime.
Less molasses—better quality.
Higher coefficient of purity.
But one attendant required in operation.
Minimum of pipes and fittings required.
Minimum loss of heat by radiation.
Exhaust or low pressure steam utilized.
Advantages of a superheat clarification.
Space occupied equal to two clarifiers.
All foreign matter held in suspension removed.
Mucilaginous matter less effective in restraining granulation.
Best system of measuring, liming, sampling and weighing juice.
One juice pump required, which is also the filter press pump.

THE YIELD OF SOFT SOAPS.

It may be called a rare occurrence if a soapmaker should obtain the same percentage of yield in making several boils of one kind of soft soap. In a great majority of cases, even with the same fats and lyes, a difference amounting to several per cent. will be noticed. The principal cause of this difference is the impossibility of adjusting with mathematical correctness the evaporation of water by boiling; what is ordinarily termed "normal" evaporation fluctuates between limits which account for these variations. If the evaporation of water by boiling is sufficient in itself to bring about this result, it is still further explained on considering that the yield is affected also by the fats, by the greater or less causticity of the lye, and by the addition of soda in soap for summer use.

Among the unfilled soft soaps in which potash lye exclusively has been used, the "natural grain" soaps are prominent, in making which potash lye only is used in all seasons. The different fats selected for the different seasons do not influence the yield to a degree worth mentioning, as it is not so much the tallow but especially the oils which vary. Generally one-third tallow (figured on the total of fats) is sufficient, as, for instance, in summer sufficient stearine for the proper formation of the grain is introduced by the increased proportion of cotton seed oil employed. The yield of linseed oil and of cotton seed oil may be assumed to be the same; the change in the proportions of these two oils used, therefore, has no practical influence on the amount of soap produced.

The variations frequently enough encountered in the yield of these soaps generally fluctuate between 235 and 240. This is owing principally on account of stronger evaporation of water in the case of the lower figure named, for in these soaps especially the manufacturer is careful to add potash solution if necessary to counterbalance great causticity in the lye.

The proper degree of evaporation is recognized in such soaps by observing the froth on the surface toward the end of the boiling. When the soap, having been properly made with caustic and carbonated lye, falls in the kettle during strong boiling, this is the sign that the excess of water is removed and that boiling must be discontinued shortly after. If no formation of froth is then observed on the surface when the soap has quieted down, we are justified in assuming that the soap was boiled down too strongly. (These remarks are based on boiling over an open fire, the excessive evaporation of water being here caused by either not drawing the fire soon enough or by afterheating by the heat in the furnace, etc.) In this case the yield would probably fall short of 240 per cent., and in fact there is no clew as to how much water has been unnecessarily evaporated; it is then necessary for the proper yield to add so much water during slow boiling until a very little speck of froth—about the size of a five cent piece—is seen on the surface. This affords a certainty that the proportion of water is neither too high nor too low; still there will be small variations in the weight, as frequently more or less froth is caused, which, however, does not influence the quality of the soap, and therefore requires no correction if the variation is not too far from the normal condition.

Greater differences in the yield occur in the unfilled ordinary smooth and green soaps, this being a natural consequence of the changes in the proportions of resin used and in the lyes employed. The yield of soap decreases in proportion as more soda lye is used, as less soda is necessary to saponify the oil than is required of potash. Soft soaps made of pure potash lye show a larger increase, for in a case requiring 56 parts potash lye for saponification, 40 parts of soda lye of the same strength and caust , would be quite sufficient. Then the character of the lye plays an important part in the yield. Of a very caustic lye less is of course required to saturate the oils than of one containing more carbonated alkali, for the caustic lye alone saponifies oils, while the action of the carbonated alkali is purely mechanical, and by its presence naturally increases the yield.

According to season the smooth and green soft soaps contain more or less resin. The yield is in these cases figured on the basis of the fats alone, because, on account of its low price, the resin is considered as belonging rather to the filling than to the fats.

One would think that the lye required for saponifying the resin would add to the yield of soap in the same proportion as in pure oil soap, but the writer observes that when the resin is boiled together with the oils from the start, it rarely causes an increase above its own weight, compared to the soap made without resin. For example 1,500 lb. linseed oil and 225 lb. resin (15 per cent) without using any soda lye, furnished, according to repeated weighings, 3,600 lb. soap; this is 240 per cent., figured on the 1,500 lb. of oil. The same result was obtained when 1,200 lb. linseed oil, 300 lb. cotton seed oil, and 225 lb. resin were used. Only once a percentage of 242 per cent. could be recorded. If now a pure oil soap (without resin and soda lye) is considered as yielding 228 per cent., then the 1,500 lb. of oil would yield 3,420 lb. of soap, and if we add to this merely the simple weight of resin we have 3,645 lb. or 243 per cent. against 240 per cent. actually yielded. The explanation of this deficiency can only be found in

the stronger boiling down required for soaps containing resin. The indications showing when enough water has been evaporated are the same in soap made with resin as in those without resin, but in the former they appear later, thereby causing the lower yield.

Several boils with 10 per cent. resin, made without soda lye, gave a yield of 236 per cent. The materials were 1,250 lb. linseed oil, 250 lb. cotton seed oil, 150 lb. resin.

The same soaps with only 5 per cent. resin made in the same manner, yielded from 230 to 232 per cent. Small variations occur here also, because the lyes are never quite alike, nor is the degree of evaporation.

The yield of summer soaps, as already said, depends on the use of soda lye. In this respect the use of the cheaper cotton seed oil is of advantage, for with the addition of but little soda a sufficiently solid soap results, together with a larger yield. In the very hot season cotton seed may be used almost entirely for smooth soft soaps, when of course the soda lye must be entirely omitted. In less warm weather half linseed oil and half cotton seed oil with 5 to 10 per cent. resin may be used, but it may then be well to use from 8 to 10 per cent. of soda lye to guard the soap against becoming too thin. The loss in the yield with so little soda lye will not be more than two or three per cent.

In figuring the yield in the case of filled soaps it is only necessary to subtract the weight of filling used and divide the weight of actual soap in the weight of the oils used, to get the percentage of yield. For instance, if 1,250 lb. linseed oil, 250 lb. cotton seed oil, and 150 lb. resin, with the aid of 380 lb. chloride of potash solution, make 3,920 lb. of soap, then there are 3,540 lb. of real soap; and this divided by 15 (1,500 lb. of oils) = 236 per cent.—*Seifenfabrikant; American Soap Journal.*

WIRE NETTING MACHINE.

EVERY one is acquainted with the appearance of wire netting, as shown in Fig. 2 above, which illustrates a small portion next the selvedge. It is produced by twisting together adjacent wires and bending the loops into hexagonal form. To understand the construction, let us neglect the selvedge and imagine a number of parallel wires laid side by side at distances depending on the gauge of the netting, say 1½ in. Numbering these wires 1, 2, 3, 4, 5, and 6, the first operation is to twist together Nos. 1 and 2, 3 and 4, 5 and 6, and so on. Then No. 2 is twisted with No. 3, No. 4 with No. 5, No. 6 with No. 7, and so on. At the next operation No. 2 returns to No. 1, and is twisted with it, No. 4 to No. 3, No. 6 to No. 5, and the cycle is complete. The process would be simple enough were it not for the small gauge of the meshes. The bobbins on which the wire is wound have to pass between the wires, and as the most customary size of mesh is from 1½ in. to 2 in., this is the usual limit of the diameters of the bobbins. The machine illustrated below, and constructed by the Dennis Patent Continuous Wire Netting Company, Limited, of 11 Billiter Street, London, was devised, says *Engineering*, to avoid this limitation. It will, however, help the comprehension of its mechanism if we first give a short description of the method of manufacture it was designed to supersede.

In the ordinary machine two kinds of wire are employed, one wound on bobbins of considerable capacity, the other on spools or taper spindles, called "springs." It is these latter that pass to and fro between the adjacent wires, and whose diameter is determined by the size of the mesh. Naturally the wire they contain has to be of a soft quality; hard wire would be unmanageable when it had to be drawn off the end of a spool, like yarn from a cop. The other wire is harder, to give stiffness to the netting, and the difference in the rigidity of the two can often be traced in the form of distorted loops. The springs carry only a limited amount of wire, and their repeated renewals give rise to frequent stoppages of the machine, greatly limiting its output. Figs. 3 and 4 show the most important feature in the mechanism of all wire netting machines, and one of great interest to the mechanic. For each pair of wires there is a spindle, B, carrying a pinion, G, gearing with a rack. Through this spindle are bored two holes, D, for the wires to pass through. It is quite evident that when the spindle is rotated the wires will be twisted round each other. On the side toward the net they will be bound together (Fig. 2), while on the other side the "spring" must be carried round the companion wire to prevent the two wires becoming entangled. The spring contained in a tube is, in fact, connected to the spindle. One twisting is thus produced, and the pairs of wires have now to be rearranged. It will be noticed that both the spindle and the pinion are in halves; the end of the spindle runs in a bearing formed with a top and bottom cap, and when it stops, the parting line of the spindle coincides with the parting line of the bearing. The top half of the bearing is now moved away to the right, carrying with it half the spindle (Fig. 3) and depositing it on the lower half of the adjacent spindle, which has been laid bare by its upper half having been carried off in a similar manner. All is now ready for the newly formed pairs of wires to be twisted together, after which, by a reverse operation, the old arrangement is reproduced. By this means and a porcupine roller, which shapes the meshes and feeds forward the web, the netting is produced.

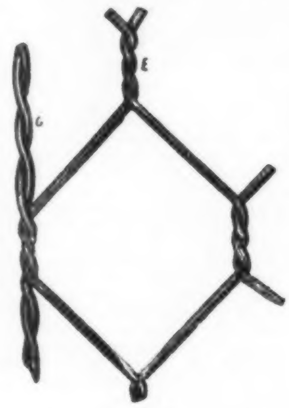


FIG. 2.

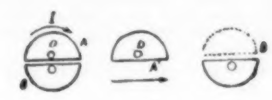


FIG. 3.

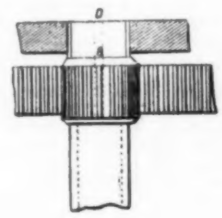


FIG. 4.

The mechanism we have just described is reproduced in its essential features, on the front stand of the Dennis machine, except that there are no springs wound on tubes attached to the half spindles. The bobbins, it will be noted, are all of a large size, and are arranged on the rear standard. One-half are supported on a stationary creel, to borrow a Lancashire word, while the other half are carried on cradles. These cradles are mounted on the ends of divided spindles similar to those we have already described; the other halves carry "fliers," not very clearly shown in the engraving. The spindles are arranged in divided bearings, arranged between a fixed external ring and an inner wheel carried on a central shaft. This inner wheel is moved to and fro the distance between a pair of spindles, to rearrange the halves to produce the meshes of the net, just like the straight frame shown in Figs. 3 and 4. The wires from the back bobbins are drawn through one set of half spindles, and are then led through the "fliers." The wires from the bobbins in the cradles are conducted through tube guides, to avoid all chance of the two wires lashing together. Each wire is kept taut by a brake on its bobbin, and all the wires are hard.

It will now be evident to the reader that in the Dennis machine the wires are twisted twice over. First they are twisted on the back frame to a very large mesh, of a size sufficient to allow capacious bobbins to be used. But as there is no market for such a web, the wires are drawn together to a pitch of 1½ in. or 2 in., or whatever is required, and again twisted. This second twisting has the effect of taking out the first, or rather of passing it forward right up to the piece of netting already formed, and the big bobbins are rendered free to "set to partners" again, and to be rotated by the pinions on the spindles and a large spur wheel not visible in the engraving. The device is very ingenious and interesting.

The following are the usual sizes of meshes and gauges of wire adopted in the manufacture of netting:

Meshes.	½ in.	⅝ in.	¾ in.	1 in.	1¼ in.	1½ in.	1⅝ in.	2 in.	2¼ in.	3 in.	4 in.
Gauges.	22	22	20	20	19	19	19	19	19	19	16
	20	20	19	19	18	18	18	18	18	18	15
		19	18	18	17	17	17	17	17	17	14
				17		16	16	16	16	16	13
						15	15	15	15	15	12
							14	14	14	14	11
									13	13	10
										12	

The width of the netting varies from 12 in. to 72 in., increasing usually by 6 in. stages. The largest size of meshes—4 in.—is only used for sheep runs. In the home trade the 2 in. mesh is most usually bought, while the 1½ in. and 1⅝ in. is mostly exported. On an average wire netting runs from about 20 cwt. to 30 cwt. a mile, the average width being 3 ft. 6 in. In the home trade it is usually sold in 50 yard lengths, and in the export trade in 100 yard lengths. In America the rolls are 150 ft. We are indebted for many of the above facts to "A Treatise upon Wire, its Manufacture and Uses," by Mr. J. Bucknall Smith.

THE colors of the waters of the Mediterranean vary considerably at different seasons of the year and in different localities. During storms and boisterous weather it assumes a deep green and sometimes a brownish tint, but when calm and undisturbed it is of a bright deep blue. In the Bosphorus and among the islands of the archipelago it is of varying tints, in some places being of a liquid blue graduating into a brighter green, and in others assuming a blue so deep in its intensity as to almost approach a purple.

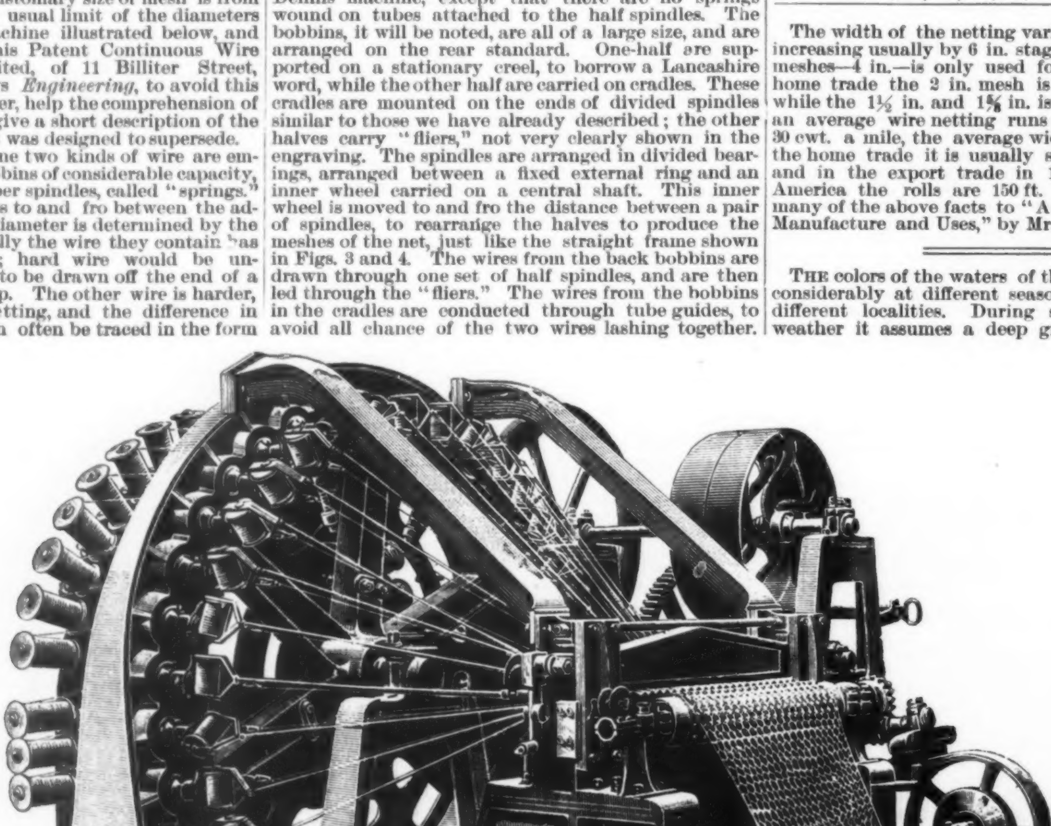


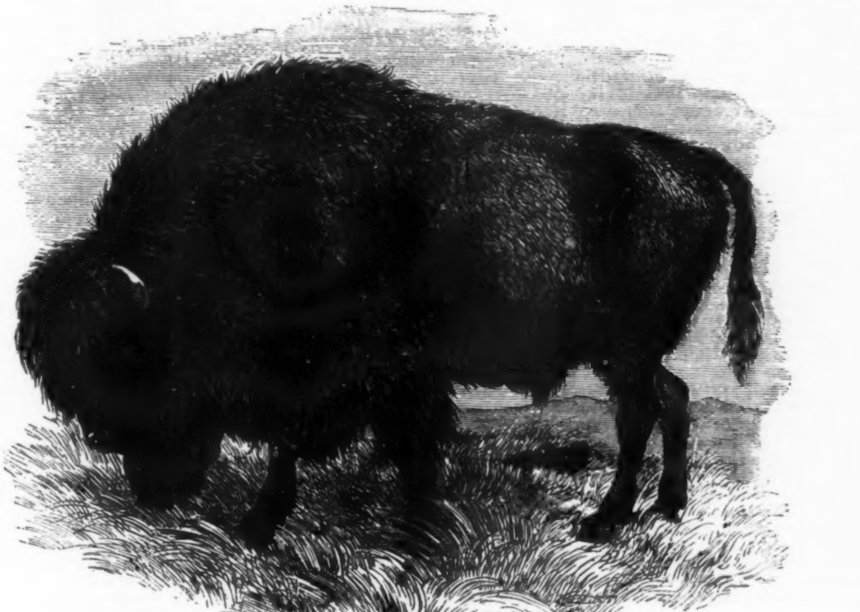
FIG. 1.

THE DENNIS CONTINUOUS WIRE NETTING MACHINE.

THE EXTERMINATION OF THE BISON.

By W. B. TEGETMEIER.

THAT the American bison—or, as it is often called, buffalo—one of the largest and most magnificent species of the ox tribe, should have been practically exterminated can hardly be considered without regret. Less than twenty-five years since the individuals existing on the prairies of North America were estimated at nearly six millions, a greater number than the whole of the inhabitants of the metropolis and the metropolitan district. When the Union Pacific Railway was completed in 1869, it cut this vast herd in two, about 4,000,000 going south of the railway and 1,500,000 remaining on the north. In ten years' time these 4,000,000 had practically ceased to exist, twenty individuals in Texas being all that remained of that vast number; and a few years afterward the same fate overtook the northern herd, some 200 wild individuals only being preserved in the Yellowstone Park, where they are now protected. It is supposed that some 500 exist in the British territory, and, with these exceptions, this magnificent race is exterminated.



AMERICAN BISON (BOS AMERICANUS).

The form and character of the animal are well represented in our engraving. The body is covered with short woolly hair, which on the head and neck is sufficiently long to conceal the ears and the base of the horns and protect the eyes. The withers are remarkably high, forming a huge hump over the shoulders. The size of the animal may be inferred from the fact that a large bull bison in the museum at Washington stands 5 ft. 8 in. in height at the withers.

Since the establishment of the railways across the great American continent the bones of the countless millions of bison that formerly existed have been collected by the Indians and half-breeds for transmission to the sugar factories in the United States, where they are made into animal charcoal for the purification of sugar. The engravings are copies of photographs taken by Mr. Launsden, and forwarded to the Zoological Society by Professor Ramsay Wright, of Toronto. They give a very good idea of the immense number of bison that must have at one period inhabited the country.

Mr. H. Launsden, writing in December last, states: "The photographs were taken by me in August, 1890, at Saskatoon, on the South Saskatchewan River, 160 miles north of Regina, on the Prince Albert branch of the Canadian Pacific Railway. In order to give you some idea of the immense number of buffaloes that must at one time have inhabited this country, I may say that at the time these were taken there were at this point piles of buffalo bones 8 ft. wide by about 7½ ft. high, and of a total length of about 800 ft. At nearly every siding between Duck Lake, some fifty-one miles north of Saskatoon, southerly to within say twenty-five miles of Regina, there were also similar piles varying in length from 50 ft. to 300 ft. or 400 ft. Nearly all these were, I believe, shipped off the line during the season of 1890, and I am informed that during the present season over 270 car loads of similar bones have been shipped from the same country to the United States, and are used, I believe, in the refining of sugar. These bones are collected by Indians and half-breeds in carts and wagons, drawn to the sidings and piled by them. They pick out the heads, pile them on the outside, and fill the interior of the piles with the other bones. I am also informed that they receive from \$5.50 to \$7 per ton for these bones."

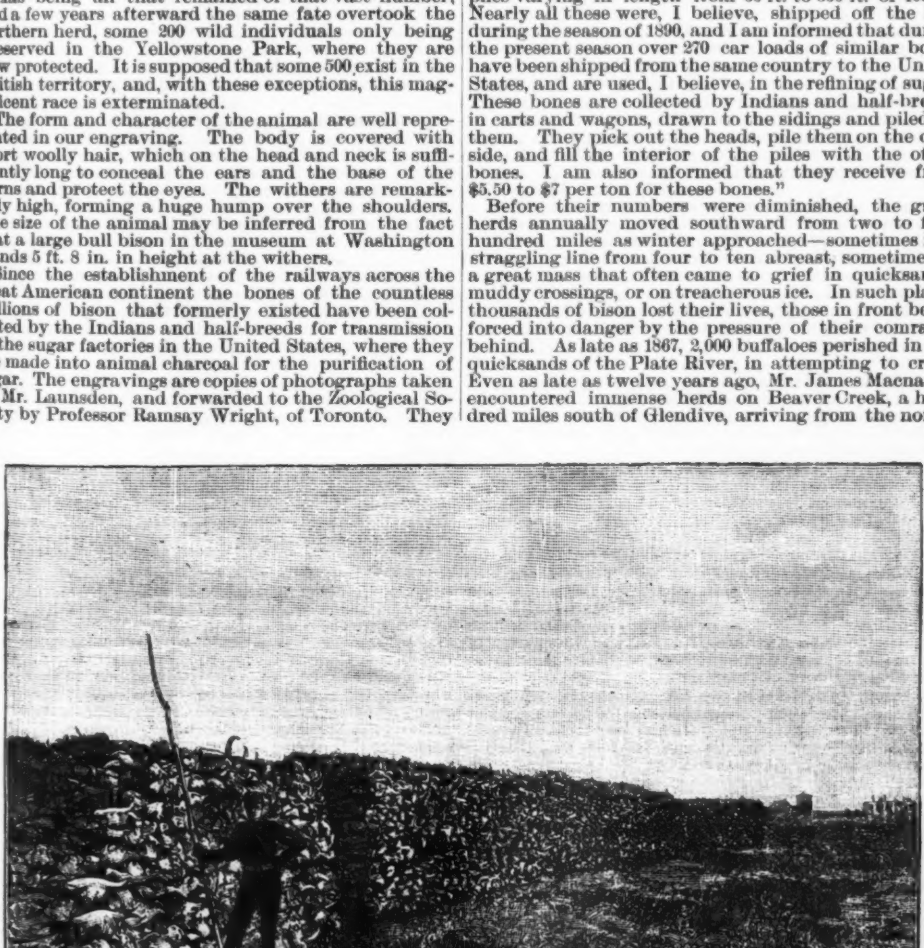
Before their numbers were diminished, the great herds annually moved southward from two to four hundred miles as winter approached—sometimes in a straggling line from four to ten abreast, sometimes in a great mass that often came to grief in quicksands, muddy crossings, or on treacherous ice. In such places thousands of bison lost their lives, those in front being forced into danger by the pressure of their comrades behind. As late as 1867, 2,000 buffaloes perished in the quicksands of the Plate River, in attempting to cross. Even as late as twelve years ago, Mr. James Macnaney encountered immense herds on Beaver Creek, a hundred miles south of Glendive, arriving from the north. As the hunters sat in their tents, they heard a low rumble, which increased to a thundering noise, caused by the trampling of a big herd of buffaloes. They ran out immediately and discharged their revolvers, to keep the buffaloes from running through their tents. Fortunately, their horses were picketed some distance away, or they would have been overwhelmed. In the morning the whole country was black with buffaloes, and it was estimated that 10,000 were in sight.

On another occasion, at the same place, a living stream of buffaloes, four to ten abreast, all going at a gallop, continued for four hours to pass the camp. The hunters fired from the tents and killed over fifty, but the herd passed on, and were observed winding through the valleys between the hills, two or three miles away. A hundred thousand beasts passed the tents during the winter of 1881-82.

The number of bison slaughtered by the Indians and sold to the American Fur Company, fifty years ago, amounted to nearly one hundred thousand yearly. Those obtained in the winter months were the only ones regarded as worth preserving, and the hides of the bulls were never taken off at any season. The final destruction of the bison was due to the construction of the railway across the plains, which opened up their ranges, and they were rapidly killed off by the skin hunters. On the opening of the rails the bison, in their ignorance, charged the trains, as thus related by Mr. Hornaday:

"At full speed, and utterly regardless of the consequences, the herd would make for the track on its line of retreat. If the train happened not to be in its path, it crossed the track and stopped satisfied. If the train was in its way, each individual buffalo went at it with the desperation of despair, plunging against or between locomotive and cars, just as its blind madness chanced to direct it. Numbers were killed, but numbers still pressed on, to stop and stare as soon as the obstacle had passed."

It is satisfactory to know that the absolute extermination of the bison is not probable. It may be bred in confinement with success, and crossed with the domestic cattle with great facility. These half-breeds are very prolific, and sufficiently hardy to face the blizzards and storms of the prairie, and to require no housing in winter. It may interest some of our readers to know that so easily is the bison domesticated that four calves were born and successfully reared during the time the Wild West Exhibition was on show at Kensington, and that more than one herd of half-breeds adorn our English parks.—*Illustrated London News.*



BISON BONES ON THE CANADIAN PACIFIC RAILWAY.

THE VICTORIA NYANZA.

THE following observations on the Victoria Nyanza have been sent to the Royal Geographical Society by Mr. Ernest Gedge, who has spent a considerable time on the lake and in its neighborhood: "The appearance of the lake suggests the formation at some remote period of a vast trough or valley; the western coasts give striking indications of this, especially in Karagwe, where the cliffs come sheer down with deep water close inshore. Inland, behind these, can be noticed a succession of lines of fault, running parallel to one another, forming a series of terraces or steps, which finally culminate in the high grassy plateaus stretching away westward.

"There is nothing either on this side or on its southern shores suggesting volcanic action; the geological structure consisting for the most part of gneissic formations and schists, with enormous bowlders of porphyritic granite, the latter constituting the most prominent feature on its southern coasts, as well as forming a remarkable island in the lake, known as the 'Makoko' or white rocks. On the northern shore outcrops of honeycombed ironstone and lava blocks are to be seen, and this change in the geological structure is accompanied by a corresponding change in the vegetation, from the sterile arid wastes so characteristic of the southern coasts to rich tropical growth.

"The main visible sources of the water supply for this great reservoir are the Kagera, Nzoia, and Ngure Darash Rivers; and these, though continually discharging a certain amount of water into the lake, are of no great size, except during the rainy season, appearing totally inadequate to maintain the equilibrium of the lake, when we consider the volume of water constantly being carried off by the Nile, as well as the loss that must be caused by evaporation from so large an area. This would lead one to suggest the existence of springs to make up the deficiency. The lake is of great depth in places, and the water fresh and clear, though flat and insipid to drink. Fish are plentiful, being mostly caught with a rod and line, the nearest approach to netting being a screen of grass mats, used as a sieve by the people in Lower Kavirondo, and the basket traps used by the Ba-Sesse. Among others is a silurus, which has evidently been mistaken for the porpoise, owing to its shiny black body and its habit of coming to the surface and indulging in porpoise-like gambols in calm weather. Hippopotami are not very plentiful, as they chiefly confine themselves to the coasts and rivers. Those that are found in the open water are, however, extremely vicious and much feared by the Ba-Sesse canoe men, who, strange to say, are unable to swim. This is no doubt largely due to the fact of the lake being infested with alligators, rendering it dangerous for any one to enter the water. Cyclonic storms of great violence occur at certain seasons, and are most dangerous to small craft. These storms in August usually occur at daybreak, coming from the southwest, with much thunder and lightning. Following the coast line for a time, they would suddenly sweep across the lake in a northeast direction, raising a tremendous sea, and on several occasions we were in imminent danger of being swamped. During this month I noticed that about 3 A. M. the wind was invariably off-shore, varying from the north-northeast to north and northwest. This would drop about 11 A. M., to be followed by a calm lasting to about 2 P. M., when the wind would again come up and blow strongly, in gradually increasing force, from the southwest to south, dying away again at night about 8 P. M. During November the prevailing wind was from the northeast. One of the most remarkable phenomena I witnessed was the apparent tide observable at irregular intervals, the waves coming in and overflowing the beach in exactly the same way as the tide on the sea

shore, the rise and fall lasting from half an hour to an hour or more. This has occurred during a comparative calm on some occasions, while on others, though a strong gale has been setting inshore, I have not noticed any difference in the lake's level; so it would seem that this occurrence is not altogether attributable to the wind backing up the water. Another curious feature is the periodical rise and fall, which, according to the natives, takes place every twenty-five years, and which is shown by the water marks on the shores. At the time of my visit the lake was between eight and nine feet below high-water mark, and the people told me that certain lands then under cultivation would again be flooded in due season, and that the peninsula on which my camp was pitched would again become an island." Similar changes of level have been noticed both in Lake Tanganyika and Lake Nyassa, and it is very desirable in the interests of geography as well as the development of the continent that continuous observations should be made, in order to discover what is the real character of these changes.

THE ORIGIN OF COAL AND PETROLEUM.*

By A. E. FORSTALL, of Newark, N. J.

THE average gas engineer finds his time so fully taken up by the routine of his position, or by investigations bearing directly upon the improvement of the processes with which he has to deal, that he has little leisure for original research in outside fields. When, therefore, the wisdom of the "powers that be" in the Western Association assigns such a subject as this for a paper, there surely can be no expectation of the development of any new and startling facts or theories. The idea must rather be to obtain a summary of facts and theories already known to and advanced by geologists, with a brief, succinct statement of the arguments for and against these various beliefs. It is from this standpoint that what follows has been written.

Geology is, from the nature of things, an indefinite science, in so far as it deals with the earlier periods of the earth's existence. Studying the effects produced by natural forces at the present day, it reasons that in the past similar effects argue the operation of the same forces. But even the record of these effects as contained in the portions of the earth's crust explored by the geologist is very incomplete, many gaps being left to be filled in by deduction, always liable to error. Any moment may bring forth some new fact, upsetting preconceived ideas and compelling a remodeling of theories. However, the theory as to the formation of coal now generally held is apparently as firmly founded as any geological speculation, and will probably never have to be materially altered. That in regard to petroleum is not so certain, but accounting satisfactorily for all the facts as known, must be accepted until some new and irreconcilable discovery is made.

Let us take up coal first. Almost all the coal known to and worked by man dates from the Carboniferous age division of the Paleozoic period, taking its name from the extent of its coal formations, and itself capable of subdivision into three minor periods; the Sub-Carboniferous, the Carboniferous proper and the Permian. It is in the measures of the second of these subdivisions that coal is principally found, in seams varying from a fraction of an inch to 40 or 50 ft. in thickness. Under each coal seam is a bed of fire clay; above it a covering of black bituminous slate. A pure, simple seam is rarely more than 8 to 10 ft. thick, the mammoth seams being formed by the running together of several seams through the thinning out of the intermediate strata, which are still to be found in very thin layers through these seams. Between the seams, with their accompanying clays and black slate, are layers of sandstone and limestone. A section through the coal measures shows a number of seams of coal, in some cases as many as 50 or 60, of various thicknesses and degrees of purity, separated from each other by intervening strata of sandstone and limestone. The vegetable origin of coal is no longer considered doubtful, and quoting from Le Conte's "Elements of Geology," we have the following as the principal evidence upon which is based the present scientific unanimity of opinion on the subject:

"*First.*—The remains of an extinct vegetation are found in abundance in immediate connection with the coal seams, stumps and roots in the under clay and leaves and stems in the black slate in contact with the seam, and even embedded in the seam itself.

"*Second.*—These vegetable remains are not only associated with the seam, but have often themselves become coal, though still retaining their original form and structure.

"*Third.*—Not only these easily recognizable embedded fragments, but the embedding substance also, the whole coal seam, even the most structureless portions and the hardest varieties, such as anthracite, when carefully prepared in a suitable manner and examined with the microscope, show vegetable cells with characteristic markings.

"*Fourth.*—A perfect gradation may be traced from wood or peat on the one hand, through brown coal, lignite and bituminous coal, to the most structureless anthracite and graphite on the other, showing that these are all different terms of the same series. In chemical composition, too, the same series may be traced.

"*Fifth.*—The best and most structureless peat, by hydraulic pressure, may be made into a substance having many of the qualities and uses of coal."

These are, in brief, the main reasons for the belief in the vegetable origin of coal. Working on this hypothesis, how can we account for the different varieties of coal, classified according to their elementary composition; that is, according to the relative amounts of carbon, hydrogen and oxygen contained in them, these being the three elements forming a pure coal? The substance that makes up the mass of the cell membranes of all plants is called cellulose, and has a composition denoted by the chemical formula, $C_{18}H_{30}O_{15}$, signifying that each molecule is formed of 18 atoms of carbon, 30 atoms of hydrogen and 15 atoms of oxygen. When vegetable matter is protected from contact with air, as it may be by being covered with water, mud, or a growth of fresh vegetation above it, a slow decomposition takes place by mutual reactions among its own elements. Carbon unites with hydrogen to form marsh gas, CH_4; also with oxygen, forming carbonic acid, CO_2, while hydrogen and oxygen unite, producing water, H_2O. These reactions are proved to take place by the continual giving off of marsh gas and carbonic acid from the coal in mines, these two gases being the fire damp and choke damp, so dreaded by miners. Analysis also shows that the bubbles which rise to the surface when we stir up the decaying vegetable matter at the bottom of a pond are composed of these gases.

Starting now with 2 molecules of cellulose, or $C_{36}H_{60}O_{30}$, by subtracting 9 molecules of CO_2, 3 of CH_4, and 11 of H_2O, we have left $C_{24}H_{26}O$—the formula for an average cannel coal. In the same way we obtain $C_{26}H_{20}O_2$—the formula for average bituminous coal—by the subtraction of 7 molecules of CO_2, 3 of CH_4, and 14 of H_2O; and finally, if we deduct 10 CO_2, 10 CH_4, and 10 H_2O we have left C_{16}, which is pure carbon or graphite. Thus reactions known to occur are shown to be capable of producing coal from vegetable matter—another strong argument in favor of this theory.

It is almost certain that bituminous coal has been formed in the manner indicated from the original vegetable matter, without the aid of heat, the strata found with it showing no signs of metamorphism. The extreme varieties of coal, anthracite and graphite, are always found, however, associated with metamorphic rocks, so that it is almost equally certain that in their case heat has played a part in the complete expulsion of the hydrogen and oxygen. Such heat need not be extreme, a temperature of 300° to 400° F. being sufficient to produce all the metamorphic effects found in the anthracite regions.

The origin of the coal thus determined, how can its accumulation in its present form of numerous seams throughout the coal measures be accounted for? This accumulation certainly took place in the presence of water. In no other way can the preservation of the original organic matter which would have decayed if left exposed to the atmosphere, the presence of interstratified layers of clay, sand and limestone, or the stratification of the coal itself, be explained. Besides, the plants found in connection with the coal seams are such as grow in moist ground. Opinion, however, is divided as to whether the growth and deposition took place on the same spot or whether the latter occurred at a distance from the original home of the plants, being brought about by the formation at the mouths of rivers of the so-called "rafts," an example of which is found at the mouth of the Red River. The theory of growth *in situ* seems most probable, agreeing better with the facts of the comparative freedom of coal from ash which is intermixed inorganic matter; the existence on top of the seams of numerous perfect specimens of the most delicate parts of plants and the number of stumps found apparently in the exact condition and position in which they grew in the under clay.

The study of the strata of the coal measures seems, also, to indicate that the forests from which the larger coal beds have been formed grew at the mouths of rivers, on low lands more or less marshy and subject to overflows from the rivers, with occasionally an incursion of the sea due to a gradual subsidence of the continent. The land area of the earth bearing then a much smaller proportion to the water than it does at the present day, the air was more saturated with moisture and consequently the climate was much warmer and more equable; water vapor, from its property of allowing luminous heat rays to pass almost untouched, while almost completely absorbing the dark rays radiated back from the earth, being one of the potent agents in storing up in the earth the heat coming from the sun. These conditions of constant moist warmth, coupled with the presence of an excess of carbonic acid in the atmosphere, produced a most luxuriant forest growth, continuing for years and forming a constantly thickening deposit of vegetable matter. Now and then an overflow of the river covered this deposit with a thin layer of sand and mud, on top of which a new seam began to form. At longer intervals an inrush of the sea put an end to vegetation and formed a stratum of limestone. But gradually the sediment brought down by the rivers built up on the sea bottom new deltas on which a new growth began and the process was repeated.

Thus by the alternate growth and submergence of vast forests, were the materials destined to produce these deposits of incalculable value formed and stored under the conditions necessary for their future transformation. Slowly, during the thousands of years of the Carboniferous period, did the energy of the sun transform the carbonic acid of the atmosphere into solid carbon; still more slowly through the succeeding eras came the changes bringing this carbon to its present form, and now, after ages of preparation, man is "unbottling the sunshine," modifying the rigors of winter and turning night into day with the rays apparently lost millions of years ago.

Turning to petroleum, we find opinion much more divided, and no such general knowledge of the subject as to warrant implicit belief in any particular theory. The various theories may be divided into two classes; those asserting a derivation from the chemical reactions of minerals or inorganic matter and those claiming an organic origin through the decomposition of vegetable or animal matter.

The theories of Berthelot or Mendeljeff are leading examples of the first group. According to the former, petroleum is formed by the action of water, carrying carbonic acid in solution, upon alkali metals existing in a free state and at a high temperature in the center of the earth, he having pointed out the reactions that would take place resulting in the formation of hydrocarbon compounds.

Mendeljeff's theory supposes the existence in the interior of the earth of metallic iron and metallic carbides at a high temperature, which, by contact with water, would generate metallic oxides and hydrocarbon compounds.

Both theories consider the production of petroleum as continuous, the vapors rising as they are formed and condensing to liquids in the porous strata of the oil fields, thus making the supply inexhaustible as long as the necessary minerals and water exist.

But these theories, though chemically perfect, are not generally accepted by geologists, since they do not accord with geological facts, which point more to the organic origin of petroleum; that is, to its derivation from the decomposition of vegetable or animal matter originally contained in the rocks in which it is found, or in closely associated strata. As we saw in considering coal, the decay of vegetation at ordinary temperatures, when taking place out of contact with air, produces marsh gas. Peat bogs yield inflammable gases, and sometimes also members of the bitumen series closely allied to petroleum and asphalt, thus showing the decomposition of organic matter to be competent to produce petroleum.

There are two views as to this method of decomposition: One, that it is a primary decomposition of organic matter in or associated with the strata where the oil is found—the production, therefore, being *in situ;* the other, that a primary decomposition of the organic matter to hydrocarbon compounds first takes place, from which compounds oil and gas are derived by distillation and carried by hydrostatic pressure to the overlying porous strata, which act as reservoirs.

The chief exponent of the theory of primary decomposition is Prof. T. S. Hunt, who holds that petroleum is principally derived from animal remains contained in limestone rocks, though he admits a few cases of vegetable origin.

The theory of distillation is most fully stated by S. F. Peckham, in the report on petroleum contained in the tenth volume of the "Special Reports of the United States Census of 1880." He considers that petroleum was formed by distillation principally from beds of shale containing fucoid plants and animal remains, with limestone as a minor source, basing this view upon the variations in composition of petroleum found in different portions of the same field, which he thinks can only be accounted for upon the theory of fractional distillation. In the case of the Pennsylvania oil field, the oil is derived principally from vegetable remains in rocks far below the present level of oil occurrence, the heat for its distillation having been supplied by the causes that resulted in the upheaval of the Appalachian mountain system, and the evidences of this heat are to be found deep down beneath the unaltered rocks in which the petroleum is now stored. Peckham also considers the occurrence of large veins of solid bitumen in fissures and metamorphic rocks as a further proof of the fact of distillation.

In Vol. VI. of the "Reports of the Geological Survey of Ohio," Prof. Edward Orton, the State Geologist, discusses the subject of the origin of petroleum quite extensively, reviewing the various theories given above, indicating their weak points, and stating his own views, derived from a special study of the Ohio fields in connection with a general study of the whole subject. Admitting the great want of definite information that prevents any theory from being accepted as perfect, he inclines toward the idea of primary decomposition as the great factor in the production of petroleum, a decomposition including both vegetable and animal matter, according to location. Thus the large amounts of nitrogen and sulphur in the Lima and California oils, the unstable character of the latter, and their presence in limestones filled with animal remains, are strong proofs of an animal origin. These limestone oils are dark and heavy, with a rank odor, and are easily distinguished from the oils of a probable vegetable origin, such as the Pennsylvania type, coming from bituminous shales and found in sandstones.

As an argument against the theory of distillation, Prof. Orton cites the fact that the study of the rocks underlying the Ohio oil fields, by means of borings carried 1,800 ft. below the oil-bearing strata, shows no signs of metamorphism, which, as this depth is below the only known sources of oil supply of the Pennsylvania type, would seem to condemn the idea of distillation. In favor of the theory of primary decomposition, he notes the fact that, at the present day, in Trinidad, beds of slate formed in comparatively recent times beneath the sea, but now raised above its level and containing abundant vegetable remains, are yielding petroleum in large quantities by direct decomposition of vegetable tissues, this petroleum passing into asphalt as a result of exposure to the atmosphere. But if the action took place where the petroleum could be stored out of contact with the air, it would remain as petroleum. This is what has happened in the oil fields. A tropical climate seems necessary for this action.

Applying the views derived from the foregoing facts to explain the origin of the oil of Eastern Ohio and Pennsylvania, the following theory is worked out: These fields were the site of a tropical sea, upon the floor of which the shales constituting the chief source of the oil were accumulated. The rivers emptying into this sea laid down sedimentary deposits of clay and sand, with occasional gravel bars. In the sea itself was a vast development of marine vegetation. Some of the especially abundant plants had very resinous spores and spore cases, which were set free in enormous quantities, and, in connection with other portions of these and similar plants, were carried to the bottom in a macerated condition, there to pass through the coaly transformation, resulting in the structureless carbonaceous matter that constantly characterizes black shales, and that can still be made to yield by destructive distillation members of the bitumen series. The shales thus slowly accumulated at the bottom of this gulf must have behaved as similar shales do now, petroleum and bitumen being formed as in the case of the Trinidad shales. The petroleum was absorbed by the particles of clay in contact with it, or if formed in the water, was caught by floating particles (clay possessing the property of absorbing oils in a marked degree), being carried by them to the floor of the sea as the sediment deposited. This process continued until the materials were exhausted, producing a shale much richer in petroleum than any portion of it is at the present time. Over this was laid a bed of porous sandstone, saturated with sea water and roofed in by a very fine-grained shale. Then, by a slow system of exchange between sandstone and shale, the oil reached its final reservoir.

Prof. Orton claims that this theory finds more support in the present processes of nature than that of distillation, as we see the bitumen series forming today by the apparent primary decomposition of organic matter under normal conditions, while on the other hand we do not find this series in any case open to observation and measurement as a result of secondary decomposition, unless the comparatively high temperatures of destructive distillation are reached. Still he admits that every theory in regard to petroleum is

* Read at the recent annual meeting of the Western Gas Association at Detroit.—*American Gas Light Journal.*

merely provisional, and none can be accepted as final. He summarizes his views as follows:

First.—Petroleum is derived from organic matter.

Second.—It is more largely derived from vegetable than from animal matter.

Third.—The oils of the Pennsylvania type result from the organic matter of bituminous shales; that is, they are of vegetable origin.

Fourth.—The oils of the Canada or Lima type are derived from the organic matter in limestones, and are, therefore, probably of animal origin.

Fifth.—Oil was produced at normal rock temperatures; that of the Ohio field at any rate certainly not being the result of a destructive distillation of bituminous shales.

Sixth.—The stock in the rocks is practically complete, for though the production is still going on, the rate is so slow as to make no appreciable increase in the amount already produced, in any ordinary space of time.

Prof. Orton's views have been given thus fully because he is the latest writer on the subject, and his ideas, being based upon a broad study of the whole field, are probably the most reliable. But according to his own statement the final word cannot yet be said as to the origin of petroleum.

From what precedes, it is seen that though coal and petroleum are of similar, they are not of the *same* origin; are not necessary correlative; nor is petroleum a product of the transformation of vegetable matter into coal. The difference in the product of the two operations, one being a solid in all stages of its transformation, while the other is a very volatile liquid, may account for the greater certainty with which the record of the first can be traced through all its successive steps, and the almost total absence of record in the case of the second. As more is learned, however, by the development of new oil territory, and a more systematic study of the facts revealed by the drill, the theories of the origin of petroleum may be put upon as firm a basis as those relating to coal. Until then the gas man must accept the dicta of geological oracles, and keep at the, to him, more important task of working out the best method for the destruction of petroleum, without being absolutely certain as to its origin.

EXAMINATION QUESTIONS IN CHEMISTRY AND PHYSICS.

WITH MODEL ANSWERS.

THE following are the questions given to candidates for the Major examination in London recently, and to these we append model answers by an experienced "coach." Although the answers are, perhaps, somewhat fuller than the time actually allowed at the examination would have permitted, they make no pretensions to exhaust all that can be said on the various subjects.

CHEMISTRY—(Morning).

(Three hours allowed.)

Question 1. *Define isomerism and point out its various forms, giving examples.*

Answer. When two or more substances are composed of the same elements in the same proportions, they are said to be *isomeric* with each other.

There are three principal varieties of isomerism—namely (*a*) Isomerism proper. This occurs when the substances not only contain the same elements in the same proportions, but also possess the same vapor density and exhibit similar behavior under the influence of various reagents. Such substances are recognized as being chemical individuals by differences in boiling or melting points, action upon polarized light, and the like. As examples of this kind of isomerism may be mentioned the three di-brom derivatives of benzene, all of which may be represented by the molecular formula, $C_6H_4Br_2$.

(*b*) Metamerism. In this the substances resemble each other in percentage composition and vapor density, but differ, not only physically, but also in their behavior with reagents. Examples: Depropargyl and benzene, which have the common formula, C_6H_6.

(*c*) Polymerism. In this case the substances, while agreeing in percentage composition, have different vapor densities, and hence different molecular weights. Examples: Aldehyde, C_2H_4O; and paraldehyde, $C_6H_{12}O_3$.

Question 2. *How is calcium hypophosphite prepared? Give the equation. Why is the gaseous product of the reaction spontaneously inflammable? Account for the basicity of phosphorous and hypophosphorous acids respectively by a reference to their constitutional formulæ.*

Answer. Calcium hypophosphite is prepared by boiling together phosphorus and milk of lime until the evolution of phosphine (PH_3) ceases, filtering the solution, passing a current of carbon dioxide through the filtrate to precipitate any excess of calcium hydrate, again filtering and evaporating with agitation until a dry product is left.

The following equation approximately represents the reaction:

$$3Ca(OH)_2 + 2P_4 + 6HOH = 3Ca(PH_2O_2)_2 + 2PH_3.$$

A little calcium phosphate is, however, also produced, and the evolved gas contains a trace of the vapor of the liquid phosphide of hydrogen P_2H_4, and it is to this circumstance that its spontaneous inflammability is due.

Phosphorous acid usually appears to be dibasic, only two of its three hydrogen atoms being replaced by metals under ordinary circumstances; but a sodium salt $P(ONa)_3$ has been obtained, and tri-ethyl phosphite, $P(OC_2H_5)_3$, is comparatively well known. Hence it is better to regard phosphorous acid as being really tribasic, and to give it the formula:

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  /OH
P—OH
  \OH
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Hypophosphorous acid is generally represented as—

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  /H
P—OH
  \OH
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i. e., as phosphine in which two atoms of hydrogen have been replaced by hydroxyl. This formula, however, does not explain the fact that it always acts as a monobasic acid. If we regard the phosphorus as a pentad in this compound, and asign the following formula,

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      /H
O = P—OH
      \H
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the basicity is explained.

Question 3. *Give a process for the preparation of ethyl iodide, and describe the properties of the compound. What is its reaction with metallic zinc?*

Answer. Ethyl iodide may be obtained by gradually adding iodine to a mixture of red phosphorus and strong alcohol placed in distilling flask with a suitable condensing apparatus attached. When the reaction is complete, the iodide may be distilled off, washed with water, and redistilled from calcium chloride.

It is a colorless liquid, becoming red on exposure to light; it is nearly twice as heavy as water, and boils at 72° C.

When ethyl iodide is heated with zinc alone, a mixture of ethane and ethylene is obtained, these bodies resulting from the decomposition of the butane at first produced. This is shown in the following equations:

(1) $Zn + 2C_2H_5I = ZnI_2 + C_4H_{10}$.
(2) $C_4H_{10} = C_2H_6 + C_2H_4$.

In the presence of water zinc produces ethane only:

$$2Zn + 2C_2H_5I + 2H_2O = ZnI_2 + 2C_2H_6 + Zn(OH)_2.$$

Question 4. *What is ethylene, and to what class of bodies does it belong? Name its principal derivatives, and show how they may be prepared from it.*

Answer. Ethylene is the name now usually given to the substance formerly known as "heavy carbureted hydrogen," or "olefiant gas." It has the formula C_2H_4, and is prepared by the action of dehydrating agents, such as sulphuric acid upon alcohol. It belongs to the unsaturated group of fatty hydrocarbons, and is a type of the olefine, or C_nH_{2n}, series.

Among the derivatives of ethylene may be mentioned:

(1) The dihaloid compounds formed by direct addition. Thus, when ethylene is passed into bromine, ethylene dibromide is formed:

$$C_2H_4 + Br_2 = C_2H_4Br_2.$$

(2) Glycol $C_2H_4(OH)_2$, which may be made by treating ethylene dibromide with silver acetate, thus obtaining ethylene diacetate, which, when distilled with caustic potash, yields glycol.

1. $C_2H_4Br_2 + 2AgC_2H_3O_2 = 2AgBr + C_2H_4(C_2H_3O_2)_2$
2. $C_2H_4(C_2H_3O_2)_2 + 2KOH = 2KC_2H_3O_2 + C_2H_4(OH)_2$

(3) Glycollic acid, $HC_2H_3O_3$, made by the oxidation of glycol by platinum black:

$$C_2H_4(OH)_2 + O_2 = HC_2H_3O_3 + H_2O.$$

Question 5. *Describe the sources, characters, and chemical constitution of succinic acid, and indicate its relation to tartaric acid.*

Answer. Succinic acid may be obtained (1) from amber, in which it exists ready formed; (2) by the fermentation of a mixture of the juice of mountain ash berries, chalk, water, and decaying cheese, afterward decomposing the calcium succinate produced with dilute sulphuric acid; (3) by the fermentation of saccharine solutions, when a small quantity of this acid is always formed; (4) by the action of nitric acid upon many fatty substances; (5) by the reduction of tartaric acid by hydriodic acid. Succinic acid is a colorless crystalline body soluble in water and in alcohol, and melting at 80° C. Its salts give no precipitate with hydrochloric acid, but white barium succinate with barium chloride, and reddish ferric succinate with ferric chloride.

The constitution of the acid is represented by the graphic formula:

```
CH2CO2H
|
CH2CO2H
```

and its relation to tartaric acid is shown by describing the latter body as di-hydroxy-succinic acid, and regarding it as derived from succinic acid by the substitution of two molecules of hydroxyl (OH) for two atoms of hydrogen.

Question 6. *What is the constitution of glycerine, and how has it been determined?*

Answer. Glycerine is a trihydric alcohol and is represented by the formula

```
CH2OH
|
CH OH
|
CH2OH
```

The following are among the considerations which have led to the view of constitution symbolized by the above formula.

(1) By the action of hydrochloric acid and pentachloride of phosphorus one, two or three atoms of chlorine can be substituted for one, two or three atoms each of hydrogen and oxygen, thus proving the existence in glycerine of three hydroxyl groups.

(2) Three classes of ethereal salts are obtainable from glycerine by treatment with acids, one, two or three molecules of water being set free in the reaction.

(3) The fact that two isomeric mono- and di-chlorhydrins exist is best explained by assuming the truth of the formula given above.

Question 7. *Give a general account of the carbohydrates, showing the principle upon which they are classified.*

Answer. A carbohydrate is defined as a body composed of carbon, oxygen and hydrogen, the two latter being in the proportion necessary to form water. They mostly occur naturally in animals and vegetables, and may be represented by one or other of three formulæ, and hence fall naturally into three groups, which are:

I. Glucoses. Formula $C_6H_{12}O_6$; the principal members being dextrose, lævulose and galactose.

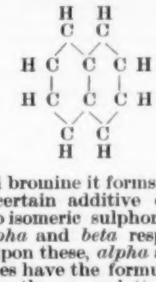
II. Saccharones or saccharoses. Formula $C_{12}H_{22}O_{11}$. The principal members are cane sugar, or sucrose; milk sugar, or lactose; and malt sugar, or maltose. They are considered to be of an alcoholic nature, and may be regarded as formed by the union of two molecules of a glucose with elimination of one molecule of water.

III. Amyloids or amyloses. Formula $(C_6H_{10}O_5)_n$. The principal members are starch, inulin, dextrin and cellulose. They may be looked upon as derived from *n* molecules of glucose with elimination of *n* molecules of water—

$$(C_6H_{12}O_6)_n = (C_6H_{10}O_5)_n + (H_2O)_n$$

Question 8. *Give the chemistry of naphthalene. What are its uses in the arts?*

Answer. Naphthalene is a very frequent product of the action of high temperatures upon organic substances. Hence it is obtained during the destructive distillation of coal, and may also be made by passing the vapor of benzine and some other substances through a red-hot tube. From a careful study of the reactions of naphthalene and its derivatives, the molecule of this hydrocarbon is regarded as consisting of two benzene rings so arranged as to have two carbon atoms in common. Thus—



With chlorine and bromine it forms substitution derivatives and also certain additive compounds. With sulphuric acid two isomeric sulphonic acids are produced, called *alpha* and *beta* respectively. By the action of potash upon these, *alpha* and *beta* naphthols result, which bodies have the formula $C_{10}H_7(OH)$, and bear to naphthalene the same relation that phenol bears to benzene. By the action of nitric acid nitro-naphthalenes are formed, by the substitution of the radical NO_2 for hydrogen, and, by the reduction of these compounds, naphthylamines, containing NH_2, can be obtained.

The principal products of the oxidation of naphthalene are dinaphthyl ($C_{20}H_{14}$), phthalic acid ($C_6H_4(CO_2H)_2$), and naphthoquinone ($C_{10}H_6O_2$).

Naphthalene is used (1) To increase the illuminating power of coal gas. (2) As a disinfectant, and to prevent moths and other insects from attacking articles of clothing and the like. (3) As a starting point in the manufacture of several dyes, *e. g.*, Magdala red, campobello yellow, naphthazarin, etc. (4) In the manufacture of benzoic acid.

PHYSICS—(Afternoon).

(Three hours allowed.)

Question 1. *State the law governing the diffusion of gases and describe an experiment in illustration of it.*

Answer. This law may be formulated as follows: Gases diffuse into each other in the inverse ratio of the square roots of their densities. As an illustrative experiment a glass tube about a foot in length may be closed at one end by a plate of plaster of Paris, filled with hydrogen, and then placed in a vessel of water so that the open end dips below the surface. The density of air as compared with that of hydrogen is as 14·4 is to 1, therefore the rate at which the air will pass through the porous plate into the tube will be to the rate at which the hydrogen will pass through the plate out of the tube as sq. 1 is to sq. 14·4. The result of this will be that the tension of the gas in the tube will be diminished and the water will rise considerably in the tube. The experiment may be varied by putting air instead of hydrogen into the tube and then inverting over it a bell jar filled with hydrogen. This gas will pass into the tube more quickly than the air will pass out, and hence the level of the water in the tube will be depressed.

Question 2. *Define specific and atomic heat, and give a process by which the specific heat of a solid may be determined.*

Answer. The specific heat of a substance is the amount of heat required to raise unit mass through unit interval of temperature as compared with the amount required to raise the same mass of water through the same interval.

The atomic heat of an element is the product obtained by multiplying together its specific heat and its atomic weight. To determine the specfic heat of a solid a known weight may be heated and then plunged into a known weight of cold water. If the initial temperatures of the solid and water be known, and the rise in temperature of the latter be accurately determined, the specific heat of the solid may be calculated by the use of the following formula:

$$\text{Specific heat} = \frac{M(T - t_2)}{m(t_1 - T)}$$

Where M = weight of the water, m = weight of the solid, t_1 = initial temperature of the body, and t_2 = initial temperature of the water, and T = the final temperature.

Question 3. *Describe the construction and principle of a bichromate battery cell, and represent the reactions which take place in it by equations.*

Answer. A bichromate battery cell consists of a plate of zinc as the negative, and one of carbon as the positive pole. These are immersed in diluted sulphuric acid, in which bichromate of potassium is dissolved. The object of the bichromate is to prevent what is called internal polarization, *i. e.*, the adhesion of evolved hydrogen to the carbon, which would tend to arrest the action of the battery. The method in which this polarization is prevented is apparent from the following equations, which show that the hydrogen, instead of being evolved in the free state, effects the reduction of the bichromate:

(1) $K_2Cr_2O_7 + 2H_2SO_4 + H_2O = 2KHSO_4 + 2H_2CrO_4$.

It is to the formation of the chromic acid that the deep color of the solution is due.

(2) $Zn + H_2SO_4 = ZnSO_4 + H_2O$.
(3) $2H_2CrO_4 + 3H_2 = Cr_2O_3 + 5H_2O$.
(4) $Cr_2O_3 + 3H_2SO_4 = Cr_2(SO_4)_3 + 3H_2O$.

Question 4. *Define the terms "electrode," "electro-*

lyte," "ion," and mention any technical applications of electrolysis with which you are acquainted.

Answer. When it is desired to decompose a liquid by an electric current, the ends of the wires dipping into the liquid and bringing the current from and to the battery are called *electrodes*, and any liquid which suffers decomposition when it conducts a current is called an electrolyte. When a substance undergoes electrolysis its molecules are rent into two parts, called *ions;* thus, if hydrochloric acid be electrolyzed, the hydrogen and chlorine into which the acid is broken up are so named.

Electrolysis receives technical application in the arts of electro-gilding and electro-silvering, as well as in many metallurgical operations.

Question 5. *Show what occurs when a ray of light falls at an angle upon a plate of glass with plane parallel sides.*

Answers. The ray, on entering the glass, will be bent or refracted toward the perpendicular to the surface in such a way that the sine of the angle of refraction will be to the sine of the angle of incidence as 2:3; on leaving the glass and emerging into the air the ray will be refracted away from the perpendicular, so that the sine of the angle of refraction will be to that of the angle of incidence as 3:2.

It will, therefore, on the construction of a diagram, be at once evident that the direction of a ray after passing through the glass will be parallel to its direction before entering. The whole of the ray will not, however, be thus transmitted; a portion will be reflected in accordance with the laws of reflection, namely:

1. The angles of incidence and reflection are equal.
2. The incident ray, the reflected ray, and the perpendicular to the surface at the point of incidence are in the same plane.

If the angle of incidence be small, the light reflected will be but a small fraction of the whole, but this fraction becomes greater as the angle increases. If the light be incident at a particular angle, called the polarizing angle, both the reflected and the transmitted ray will be found to have undergone a certain degree of polarization.

Question 6. *Distinguish between radiant heat and light, and give some method by which they may be separated.*

Answer. There is no essential difference between radiant heat and light; both are forms of radiant energy, and consist of vibrations passing through the ether. The solar spectrum, for instance, is composed of an infinite number of rays varying in refrangibility, only certain of which excite in the human eye the sensation of vision, and hence are light rays properly so called. Of these visible rays some only—namely, those of lower refrangibility—have a sensible heating effect, which they share with the dark rays beyond the red.

By passing a beam through an aqueous solution of alum the light will be but little decreased in intensity, while the heat will in great measure be arrested.

By passing a beam through a solution of iodine in carbon bisulphide the light may be completely shut off, while much heat is transmitted.

Question 7. *What is meant by the "plane of polarization"? How is it affected by a solution of glucose?*

Answer. In a beam of common light the vibrations occur in all planes perpendicular to the direction of the beam, but in a beam of polarized light the vibrations are confined to a single plane, called the plane of polarization.

A solution of glucose rotates the plane of polarization to the right.—*Chemist and Druggist.*

THE PREPARATION OF GOOD EAU-DE-COLOGNE.

APOTHECARY LEOP. TOMCSANYI states that the chief condition to the achievement of a perfect preparation is prolonged storage. According to him, the production of this world-famous article at its original home in Cologne is carried on in the simplest manner. The ethereal oils are first mixed with the wine spirits, and this mixture, after two months' digestion, is distilled at gentle heat. The preparation is then placed in kegs and removed to the cellar, where it lies five or six years, and only then is placed on the market.

The original recipe of the so-called Springbrunn water, with the peculiar odor recalling that of orange peel, according to the author, is as follows:

℞ Ol. aurant. cort.	āā	30·0
" citri cort.		
" bergamott		12·0
" neroli bigarad		1·0
" neroli petal		2·0
" rosmarini		4·0
Spir. vin. rectificatiss.		

Another water sold, which has an odor more resembling that of orange blossoms, has the following formula:

℞ Ol. aurant. cort		26·0
" citri cort		34·0
" bergamott.	āā	14·0
" aurant. flor.		
" rosmarini		
Spir. vin. rectificatiss		8000·0

The apothecary, who usually produces smaller quantities of eau-de-Cologne for his own purposes, is denied the opportunity of storing it for many years. He must, therefore, depend upon the excellent quality of the ethereal oils and the purity of the alcohol. In the preparation of eau-de-Cologne, it is best to employ two kinds of spirit—ordinary wine spirit and corn brandy. Of the ethereal oils, mixed in accordance with the proper formula, one part is dissolved in 1,000 parts of corn brandy, the remainder in 3,000 grains spir. vin. rectificatiss. The mixtures are set aside for several days in separate vessels in a cool place, then poured together and distilled.

Distillation may be avoided in the production of small quantities. In lieu thereof, the mixture is kept warm for several minutes in a glass vessel corked with cotton and immersed in water at 60° C. It should, of course, be added that the fine quality of the preparation can only be secured through distillation.

Artificial "ageing," that is, the obtaining of the finest flavoring through long storing, is achieved in a peculiar manner, and, when carefully performed, the resulting eau-de-Cologne is, according to the author, quite equal to the genuine old and long-stored article. The process consists in filling a glass bottle, provided with a perforated stopper, with the distilled water. Into the stopper introduce a spiral glass tube with narrow opening, and the bottle, inverted, is then placed in the ring of a retort stand, and underneath it is placed a bottle of a similar size with a funnel to receive the eau-de-Cologne, which trickles down drop by drop. The entire apparatus is exposed to the sun during the forenoon. When the liquid has passed from the upper to the lower bottle, reverse the bottles and repeat the operation four or five times. The forenoon sun exerts the best action, because it does not develop such excessive heat. The spiral form of the glass tube is highly important, because the liquid flows through it much more slowly, and remains longer exposed to the action of the sun.

This method can be advantageously employed in all cases where the "ageing" of a liquid is desired. The addition of spirits of sal ammoniac, recommended in many formulas for eau-de-Cologne, for achieving the characteristic effect of long storing, is not wise, since the spirits of sal ammoniac produce decomposition of many ethereal oils.

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